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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

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The Annual Meeting

THE program for the Sixteenth Annual Meeting of the Society which is to be held in New York City Jan. 11 to 13, is set forth herewith. Judging by the number of Dinner and Carnival reservation blanks which are coming in with each mail the attendance will be very gratifying to the committee members who are working diligently to maintain the reputation of this event. The program for the technical features has been arranged to cover those subjects of greatest interest at this time and sessions will be run simultaneously to enable a member to select the meeting relating to the subject nearest to his work. This innovation also allows more time for discussion of each particular subject and makes possible a more comprehensive presentation of the problem under consideration. Fourteen papers were presented at the Annual Meeting of 1920 and 14 at the 1920 Summer Meeting. There will be at least 22 papers for the coming Annual Meeting as a result of the decision of the Meetings Committee to hold simultaneous sessions. All of the technical meetings will be held in the Engineering Societies Building, 29 West 39th Street, where the general offices of the Society are located.

The semi-annual meeting of the Standards Committee will take place Tuesday morning and afternoon, Jan. 11. B. B. Bachman, chairman of the Standards Committee, will preside at these sessions and the chairmen of various Divisions will report on work done since the Summer Meeting. Several proposals for new standards and recommended practices will be discussed and voted on by the Standards Committee prior to submission to the general membership ballot.

SESSIONS

Since it is improbable that an Aeronautical Show will be held this winter it has been decided to hold the usual aeronautic sessions as a part of the Annual Meeting. The first is scheduled for Tuesday evening, Jan. 11, and will be presided over by Glenn L. Martin, second vice-presdent representing aviation engineering. C. D. Hanscom will outline the development of wing sections during the past year, discussing particularly the aerodynamic characteristics of the thick internally braced wing and sections suitable for effecting variable camber. Grover C. Loening will present a paper on recent airplane structural developments such as the all-metal plane, internally braced monoplane and retractable landing chassis. Major Thurman H. Bane will tell of the last six months' work of the engineering division of the Air Service at McCook Field, illustrating his talk with stereopticon slides and motion pictures.

The annual business meeting of the Society is planned for Wednesday morning, Jan. 12. The annual reports of administrative committees will be made at this time and officers for 1921 elected. Realizing the automotive engineer's opportunity and duty to bear a greater responsibility in industry during these times of economic readjustment, three prominent members have agreed to present their opinions regarding the Engineer's Place in Industry.

There will be three simultaneous technical sessions Wednesday afternoon, Jan. 12, covering Chassis Design for Fuel Economy, Body Engineering and Commercial Aviation. H. M. Crane, who will preside at the Chassis Session, will outline the many power losses, independent of the engine, which reduce fuel efficiency and deserve closer study. President J. G. Vincent and others have promised to express their thoughts on increased car efficiency, and the high fuel efficiencies attained by European engineers will be discussed.

The Body Engineering Session will be directed by Vice-President W. G. Wall. Several interesting papers are scheduled. Charles A. Heergeist, venerable carriage and body engineer, has prepared a statement on the reduction of body weight, and Andrew F. Johnson, educator of many of our foremost body engineers, has tendered some general remarks. George J. Mercer will handle the subject of body lines and predict the styles which he believes will prevail during 1921. George E. Goddard is planning to illustrate the steps in quantity production of all-metal bodies with some very interesting motion pictures.

The Aeronautic Session on Wednesday afternoon will be devoted to advances in commercial aviation. Glenn L. Martin will address the members. Ralph H. Upson has prepared a very comprehensive paper on the application of aircraft to the transportation of the immediate future. The development of commercial air transport lines in Europe since the war will be described by Prof. Edward P. Warner, of the National Advisory Committee for Aeronautics, who has recently returned from abroad.

Fuel Matters

Thursday morning, Jan. 13, will be occupied by a single technical session devoted entirely to the consideration of combustion phenomena of the present-day internal-combustion engine fuels. Past-President Kettering will disclose the results of extensive fuel research work carried on under his direction. The answers to a fuel questionnaire addressed to various members active in fuel problem study will be presented and discussed. The Fuel Session will be continued in the afternoon simultaneously with the Highway Session. Dr. H. C. Dickinson has some new Bureau of Standards experimental study to present and R. E. Fielder will describe a system of thermostatic inlet temperature control which has effected interesting economies as installed on the Fifth Avenue buses in New York City. The refiners' message will be carried to us at this meeting by F. A. Howard of the technical staff of the Standard Oil Co.

Past-President H. W. Alden, in opening the Highway Session on Thursday afternoon, will emphasize the responsibility of the automotive engineer in the making and maintaining of good roads. The Bureau of Public Roads has conducted a very extensive practical study of highway design during the past year and A. T. Goldbeck, the engineer of tests, who has directed this work, will present data and conclusions. The members will be specially interested in the report covering the tests on the impact of heavily loaded vehicles on the road surface. H. E. Breed, formerly Deputy State Highway Commissioner of New York, will present a paper entitled Variable Factors that Influence Highway Design, and W. E. Williams will give some suggestions on unconventional highway construction.

Carnival and Dinner

The Carnival Committee has completed all arrangements for that great social event which takes place Wednesday evening, Jan. 12. This year the large ballroom of the Hotel Astor will be specially decorated and prepared for the occasion and many surprises are in store for those attending. The Annual Dinner will be held Thursday evening, Jan. 13, also in the Astor ballroom. Mr. Kettering will carry the burden of toastmaster and that guarantees an evening with no flat spots. Reservation blanks for both Dinner and Carnival have been mailed to the members and it is advisable that all send them to the Society offices with the necessary check at once.

MOTOR BOAT MEETING

THE annual Motor Boat Meeting of the Society, held in New York City on the evening of Dec. 14, was attended by about 150 members and guests. An informal dinner preceded the technical session, Second Vice-President C. A. Criqui presiding. Mr. Criqui introduced William B. Rogers, Jr., directing editor of *Motor Boat*, who spoke briefly on the subject of standardized motor boats emphasizing the need for boats of uniform design in the smaller classes. He referred to a questionnaire circulated among the motor boat owners and builders throughout the world, the answers to which indicated the practicability of standardized designs. William Wadsworth Nutting, yachting adventurer extraordinary, narrated his thrilling double crossing of the Atlantic during the fall storm season aboard his 45-ft. auxiliary Typhoon. He outlined the entire trip but particularly stressed the encounter with an Atlantic gale off the Bermudas when the boat was swamped in the heavy seas and miraculously escaped foundering with all hands. Mr. Nutting's story was the more appreciated because of the very humorous and entertaining manner in which he told it. Henry R. Sutphen, president of the National Association of Engine and Boat Manufacturers, spoke extemporaneously on the development of the industry that would result from concentration on a few standard types of craft, and Ira Hand, secretary of the Association, called attention to the important work the Waterway League of America is doing for the advancement of motor boating.

Commander Holbrook Gibson of the Submarine Repair Base, League Island Navy Yard, Philadelphia, gave an illustrated talk on the surrendered German submarine Diesel engines which have been dismantled, reassembled and tested under his direction. He had discussed these engines at the last Motor Boat Meeting of the Society but the work of examination was not then sufficiently advanced to make possible detail consideration of such elements as the piston, connecting-rod, oiling system and reversing mechanism. The method of oil-cooling the piston-head was illustrated and the mounting of the piston-pin and bushing in the connecting-rod shown. The units described were all taken from four-cycle Diesel engines built by the Machinenfabrik Augsburg-Nürnburg, the reliability and operating simplicity of which were commended highly by Commander Gibson.

G. C. Davison contributed a paper entitled Commercial Motor Boats and the Diesel Engine, which was read by J. W. Anderson. It is generally believed that there are clearly defined fields in which one of the motor boat engine types is superior to the others, dependent upon installation and operation costs. Curves of these costs combined were presented for various horsepowers and periods of operation. Mr. Davison concluded from these curves that gasoline and kerosene engines are most economical in yachts and pleasure craft where powers are comparatively small and the boat operated less than 1500 hr. yearly. He believes that when the operation period is longer, it is more economical to select the hot-bulb or the Diesel engine, as determined by horsepower required. Diesel engines are, he thinks, superior to hot-bulb engines in sizes over 100 hp.

William Deed presented the engineering and manufacturing arguments in favor of the standardized motor boat as the naval architect views the question. He outlined the many economies resulting from continuous production of a standard type boat from the designing room, through the mold loft, mill and on to the ways.

Chairman Criqui voiced the general sentiment of gratification at the continually increasing interest and attention evinced at the S. A. E. Motor Boat sessions in the various marine engineering questions the proper handling and solution of which are essential to the advance watercraft propelled by internal-combustion engines.

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Possible Fuel Savings in Automotive Engines[1]

By H. C. Dickinson[2] and S. W. Sparrow[3]

Illustrated with Photographs and Charts

NOTHING need be said as to the importance of fuel conservation. "Familiarity breeds contempt," and the danger is that from constant discussion of this subject, its seriousness may fail to be appreciated. Nor is there any dearth of advice as to how to save fuel, either in the body of our trade journals or on the advertising pages. Unfortunately, the glowing terms of the advertisement deal too often with promises of what the carbureter, the fuel or the gas saver will do, and too seldom with records of what it has done. To be sure, the cost of fuel has not yet become a very large item in the cost of operation of most automotive appliances. In passenger cars, it is less than either tires or depreciation. A $2000 car will use some $500 worth of gasoline during its useful life and will wear out in so doing something like $800 worth of tires. What the repair bill may be depends mainly upon the driver and the repair man.

It is, however, fuel alone that is in danger of exhaustion and its conservation, therefore, is of the utmost importance. At the Bureau of Standards, the automotive section frequently has been called upon to test carbureters and fuel-saving devices of one kind or another and to pass upon their merits. As this work progressed, it became more and more evident that the difficulty of judging a given device is not so much due to inability to determine accurately what it did as to lack of knowledge as to what it should do. Of course, there was always available the ultimate test, namely, its performance on an engine with subsequent rating based on the measurements of power and fuel consumption. This, however, was not sufficient. The manufacturer who had exerted every effort to produce an inlet manifold with no sharp turns expected some statement of praise for his success in not impeding the passage of the gas to the cylinder, while at the same time the designer who had filled his manifold with a multitude of baffles expected equal commendation, for his efforts in "breaking up" the liquid. Research work, therefore, that would involve a study of some of the fundamentals of the problem and make it possible to predict the value of many of these devices without making extensive tests, seemed especially desirable.

The typical automobile engine, while representing a triumph of engineering as regards simplicity and reliability, leaves much to be desired in the way of fuel economy. At its best, running under full load and at normal speed, the thermal efficiency is from 20 to 25 per cent, i.e., this percentage of heat supplied by the fuel appears as an equivalent of work at the crankshaft. This, as it stands, is a very creditable showing, bettering that of the best steam engine by several per cent. But this is about the limit of the creditable showing. The engine seldom runs at anywhere near full load and its efficiency drops very rapidly as the load is reduced. Under ordinary road conditions, the efficiency probably does not exceed 10 per cent and of this 10 per cent, much is lost in transmission to the rear wheels and to the road. The subject of improvements in engine and vehicle design which shall result ultimately in increased mileage, is one of large possibilities and interest to the automotive engineer. However, with some 8,000,000 to 10,000,000 motor vehicles of present design in use and with an industry second in magnitude in this country, based upon and tooled for the production of present types of engine, the question of most immediate importance is: What are the possibilities of fuel savings in present types of equipment? The type of engine cannot be changed for a long time at best; and sizes of engine and car, their gear ratios and the like, can be changed only slowly. Such items as carbureters, manifolds and intake heaters can be changed more readily on new designs and to a limited extent on existing cars. Therefore, it is to improvements in fuel economy that can be brought about by such minor changes that the industry must look for immediate benefit.

Desirable Fuel and its Preparation

The problem is essentially one of diet. What kind of food shall be furnished the engine? How shall that fuel be prepared? To answer the first question is not difficult. The engine must be fed on whatever fuel is available and the only freedom of choice in the matter is in the mixture ratio, namely, the amount of air that is supplied with the fuel. The immediate possibilities of fuel conservation in existing engines can be summarized as follows:

(1) Avoid unnecessarily rich mixtures in the operation of all automotive vehicles as at present equipped
(2) Supply carbureter and manifold equipment on new and in some cases on older cars, which will make better fuel economy possible, or which will, in other words, cook the engine food according to the dictates of economy

Regarding unnecessarily rich mixtures, the numerous fuel improvers and dopes of various kinds marketed with guarantees to increase the mileage, remove carbon and generally improve the behavior of engines, are an evidence of the results which can be secured in many instances by inducing the driver to use a leaner mixture, as most, if not all, of the various improvers have absolutely no effect other than to induce the user to exercise more care in the use of the fuel. Numerous tests made for the sake of comparing average carbureter settings with the best settings for different cars have shown that without any other changes whatsoever, fuel consumption can be reduced, often by as much as 25 per cent. In fact, the long series of tests recently completed by the

[1] Paper presented at the meeting of the American Petroleum Institute, Washington, Nov. 17, 1920.
[2] M.S.A.E.—Physicist in charge of powerplants research, Bureau of Standards, Washington.
[3] M.S.A.E.—Associate mechanical engineer, Bureau of Standards, Washington.

Bureau of Mines to determine the composition of exhaust gases from average cars and trucks shows an excess fuel consumption of 25 to 30 per cent over that required for complete combustion. It must be concluded, therefore, that the average driver has his carbureter set much too rich for the best operation under average driving condition. What are some of the causes and the remedies?

An initial start with a cold engine can be obtained only when an amount of fuel equal to at least 5 per cent of the air in the cylinder is actually vaporized, or very finely atomized. With present commercial fuels, only a small percentage of the fuel will vaporize at ordinary temperatures. If, for instance, 50 per cent of the fuel can be vaporized, to secure an explosive mixture will require at least 100 per cent excess fuel.

While the time required for starting may be so short that the actual fuel loss is unimportant, the necessity of enriching the mixture makes the use of some choking device necessary and encourages the execssive use of this device while the car is in operation. Another important feature is the effect on the lubricating oil of the excess fuel that is drawn into a cold engine. The disastrous effects of crankcase dilution have been much discussed. There seems to be no question that the most serious dilution occurs in the starting and warming-up period. The saving of fuel and the prevention of crankcase dilution depend largely upon the care of the individual driver. Care in this regard will be well repaid in freedom from lubrication trouble, as well as in fuel savings.

During the period of warming up, excess fuel must be used. The same conditions apply as in starting, but to a decreasing extent. As the intake air, the intake manifold and the jackets become warm, the excess of fuel necessary to carry the requisite amount of vaporizable fractions decreases. The dash adjustment fitted on most vehicles at present permits the operator to control the mixture ratio at will. While this practice permits the careful operator to save fuel it also permits the careless driver to waste an excessive amount, and the economy which a careful operator can effect in this respect is important, particularly when a vehicle often is allowed to stand and cool off. The time required for thorough warming up is much longer than the driver is likely to suppose. The importance of properly protecting the engine when standing in cold weather should be emphasized.

It is in the setting of the carbureter for normal running that the major part of present fuel waste occurs and that the greatest savings can be secured. Two important causes for this extravagance are lack of patience on the part of the operator and an unreasonable demand for acceleration or "get away." If a carbureter is set so that the starting adjustment or dash control can be set to the lean or running position in say 5 min., or less in moderate weather with most cars, the mixture will almost invariably be too rich after another 5 or 10 min. of operation. There appears to be no remedy for this condition with present equipment, other than greater patience on the part of the driver. When there is a permanent carbureter adjustment with a dash control for warming up, the permanent adjustment should be made only after the engine has run for at least 30 min. In driving, the dash control should be set fully lean as soon as possible.

As will be demonstrated in the experimental program described later, the most obvious effects of mixture ratio on the behavior of an engine show up only when accelerating, but most driving involves frequent accelerations and, in fact, the response of the engine to a sudden throttle opening has come to be looked upon as an index of its behavior. Nevertheless, extreme performance in this regard necessarily means much waste of fuel, except in the rare cases where the intake manifold is sufficiently heated to supply a substantially dry mixture to the engine. Some sacrifice of extreme acceleration for the sake of fuel economy would seem to be amply justified, as the net results will be somewhat as follows:

(1) A saving in fuel of perhaps 25 per cent
(2) A great reduction in carbon in the cylinders, allowing probably two or three times as many miles between carbon removals
(3) An appreciable increase in maximum engine power, due to absence of carbon and a better and more rapidly burning fuel mixture
(4) Freedom from lubrication trouble attendant on crankcase dilution, assuring longer life for the engine
(5) Decreased cost of upkeep, less frequent overhauls being required
(6) A smoother running engine with less tendency to knock

In regard to carbureter and manifold equipment on new and on older cars that will make better fuel economy possible, there is considerable difference of opinion as to what constitutes the proper equipment for preparing the fuel for the engine. It is generally conceded that the food should be cooked, but it is a question whether this should be accomplished by the hot-spot manifold, concentrating the heat where the liquid strikes the walls; by the manifold completely jacketed by the exhaust so that the entire mixture is heated; or by the hot-air stove which heats only the air going to the carbureter. There still may be found some who persist in the belief that the fuel should not be cooked at all, but that it should be served in the fashion of 10 years ago when but little coaxing was required to vaporize the fuel and render it palatable to the engine. At the request of the Society of Automotive Engineers, considerable work was done in the past year toward determining the relative merits of the various methods of heating the charge.

The six-cylinder engine used in this investigation was furnished by a well-known manufacturer and exemplified good present-day design. But one change of importance was made in preparing the engine for the tests. This consisted in replacing the manifold supplied with the engine by one constructed so that it might be made to function as a hot-spot type, an entirely heated type or that type in which the air is heated prior to its entrance to the carbureter. The installation of this manifold and its construction are shown in Figs. 1 to 3.

The intake portion of this manifold was of cast iron and was surrounded by a jacket partitioned so that the exhaust gases could be made to heat the entire manifold, the tee alone, or could be by-passed, leaving the manifold cold. No comment is necessary on the apparatus for measuring the power, air flow, fuel consumption, and the numerous pressures and temperatures incident to the ordinary laboratory test.

Acceleration and Other Tests

It will not be amiss to call attention to two respects in which the equipment was unusual. The first of these was the provision for the study of acceleration. An analysis of engine requirements had emphasized the importance of ability of the engine to accelerate, to give the car what is frequently termed "pick up" or "get away." To measure this property, the so-called acceleration disc

was mounted on the dynamometer shaft. This was of steel 33 in. in diameter and ½ in. thick. Its inertia added to that of the dynamometer was about equal to that of a 3500-lb. car on direct drive with a gear ratio of 5 to 1 and 32-in. wheels. The second feature in which the set-up was novel is found in the large number of places at which temperature measurements were made. These were taken at no less than 25 points in and around the manifold.

The first series of tests was made at full load and half load at speeds of 650 and 1200 r.p.m. This covers a driving range of 15 to 25 m.p.h. In each instance, manifold conditions were as follows:

(1) Entire manifold unheated, air unheated
(2) Entire manifold unheated, air heated 30 deg. cent. (86 deg. fahr.), above (1)
(3) Entire manifold unheated, air heated 60 deg. cent. (116 deg. fahr.), above (1)
(4) Manifold tee heated, air unheated
(5) Manifold tee heated, air heated 30 deg. cent. (86 deg. fahr.), above (4)
(6) Manifold tee heated, air heated 60 deg. cent. (116 deg. fahr.), above (4)
(7) Entire manifold heated, air unheated
(8) Entire manifold heated, air heated 30 deg. cent. (86 deg. fahr.), above (7)

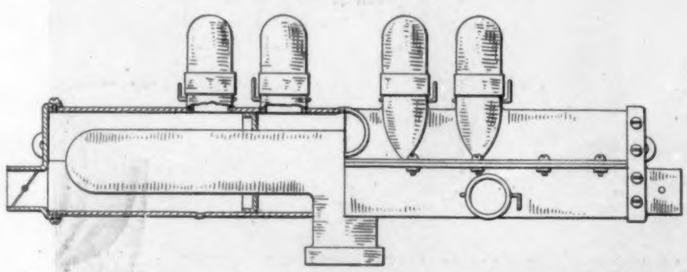


FIG. 1—SPECIAL JACKETED MANIFOLD EMPLOYED BY THE BUREAU OF STANDARDS TO STUDY MIXTURE CONDITIONS AND MANIFOLD HEATING

Figs. 4 and 5 on page 6 show the manifold under usual running conditions. Note the accumulation of liquid at the right and at the left of the tee, in the two successive illustrations. In one, at the instant of exposure, an intake valve is open at the left of the tee and, in the other, an intake valve is open at the right of the tee.

Fig. 6 on page 6 shows the manifold as it appears under good operating conditions at high engine speed, with the temperature of the incoming air at about 250 deg. fahr. Note that very little liquid is deposited on the manifold walls.

Figs. 7 and 8 on page 7 show the accumulation of gasoline in the manifold at about 10 m.p.h. when the throttle is opened wide after idling, with an air temperature of about 100 deg. fahr. Before opening the throttle, only a small amount of liquid is present. The liquid taken from the mixture to supply this amount on the manifold surface explains the difficulty and fuel waste in securing good acceleration with a cold manifold.

Fig. 9 on page 7 shows the result at 650 r.p.m. at full throttle, with an air temperature of 71 deg. fahr. The center of the tee has been heated with a brazing torch until liquid is evaporated from this portion. Note the liquid stream at the right and left of the central portion.

Fig. 10 on page 8 shows the result at 650 r.p.m. at full throttle, with an air temperature of 75 deg. fahr. One side of the tee has been heated with a brazing torch, the flame of which can be seen at the right. Note the effect of local heating in evaporating the liquid from the walls of the manifold on the right side.

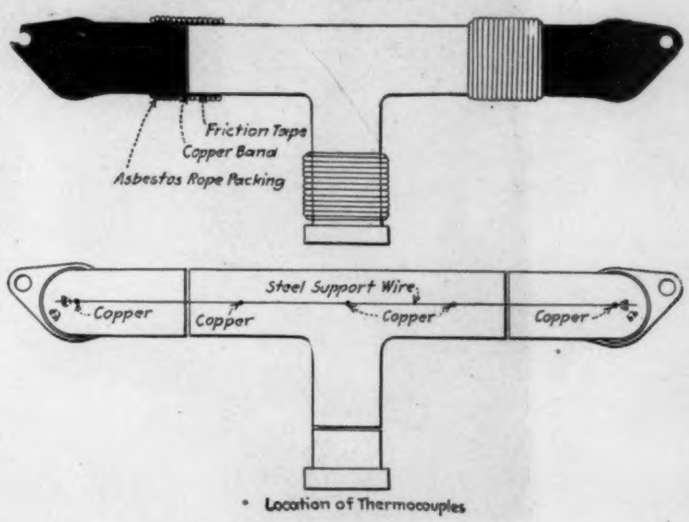


FIG. 2—THE GLASS MANIFOLD TEE

The matter of carbureter adjustment in these tests illustrates the value of planning the work so that the results shall have general application and hence be of permanent value. Had all these measurements been taken at but one carbureter setting, the data would have indicated merely the performance of this particular carbureter with this particular adjustment. Inasmuch as changing the amount of heat supplied to the charge is bound to affect the air-fuel ratio, it would have been difficult to know how much of the difference in performance to attribute to the change in heating and how much to the resulting change in mixture ratio. Instead of pursuing this course, the carbureter was given several adjustments at each temperature. Results could then be plotted to show the power developed from a given amount of fuel under the different methods of heating. Information thus obtained is not dependent upon the particular carbureter employed.

The results of two of these tests are shown in Fig. 11 on page 9. These were taken at one-half throttle at 650 and 1200 r.p.m., the conditions of heating being indicated. It will be noted that the difference between the curves is very small. The conclusion, then, is that over this range the power developed per pound of fuel is independent both of the amount of heat supplied and the point at which it is supplied. This statement must not be interpreted as applicable to every manifold. Obviously, if the area distribution of the fuel is very bad with a given manifold, fuel consumption will be reduced by the better distribution obtained by heating. It will be seen, however, that inasmuch as the type tested was of simple construction with no particular effort being made to obtain good distribution, there is little excuse for designs which are inferior in this regard.

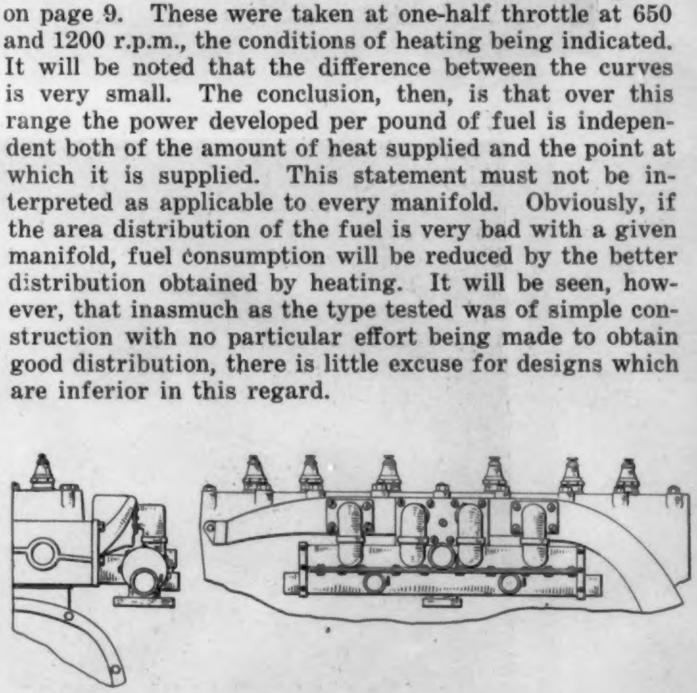
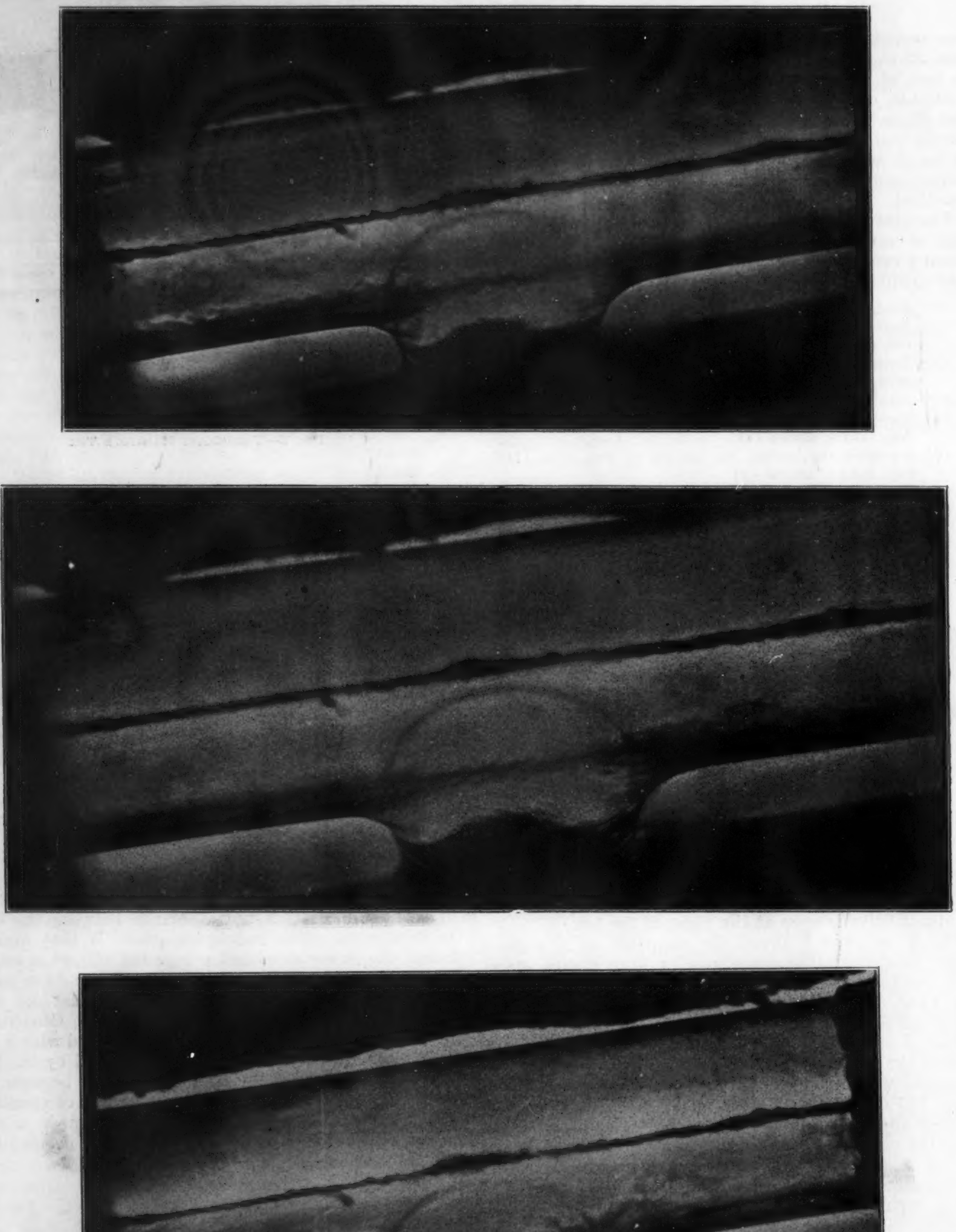
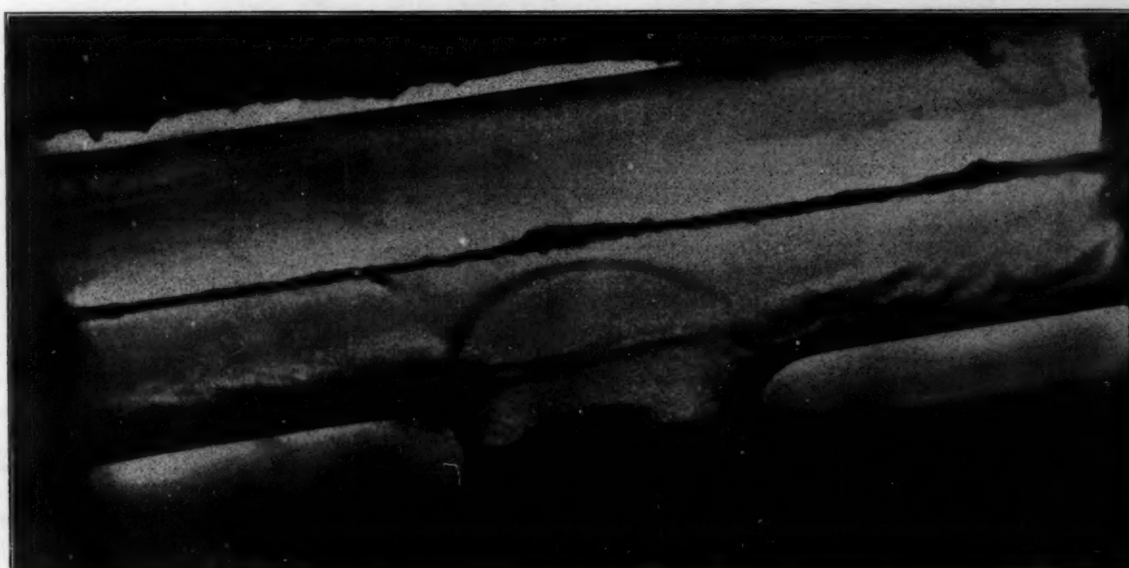


FIG. 3—THE SPECIAL EXHAUST-HEAT MANIFOLD INSTALLED ON THE ENGINE



FIGS. 4, 5 AND 6—VIEWS OF MANIFOLD UNDER OPERATING CONDITIONS



FIGS. 7, 8 AND 9—THREE MORE VIEWS OF THE MANIFOLD

FIG. 10—A VIEW OF THE MANIFOLD WITH THE ENGINE OPERATING AT A SPEED OF 650 R.P.M. AND THE THROTTLE FULLY OPENED

JACKET-WATER TEMPERATURE AND INTAKE-MANIFOLD PRESSURE

There are two other subjects which receive considerable attention whenever fuel economy is discussed. These are the jacket-water temperature and the pressure in the intake manifold. It is asserted that with low jacket-water temperatures, the cool cylinder walls fail to supply sufficient heat to vaporize the fuel properly. As to the manifold pressure, there have been extraordinary claims made as to the better vaporization obtained when the intake is under a considerable suction and the boiling point of the fuel lowered because of this reduced pressure. Thus far, there has been opportunity to touch on but one phase of this problem. The results, however, are decidedly illuminating. Two series of tests were made: in the first of which the temperature of the water entering the jacket was maintained at 72 deg. cent. (162 deg. fahr.) and in the second at 22 deg. cent. (72 deg. fahr.). Runs were made at full load, also at 0.8, 0.6, 0.4 and 0.2 of full load, with five carbureter adjustments at each throttle setting. From these results, the minimum fuel consumption for each setting has been selected and plotted in Fig. 12. It will be apparent that the fuel consumption per unit power based on brake horsepower is considerably higher with the cold jacket water. Before drawing any rash conclusions as to the cause of this difference, it will be worth while to consider the lower curve. The same results are here given with the fuel consumption based upon the indicated horsepower of the engine; that is upon the power developed by the fuel in the engine cylinder. On this basis, the consumption is independent both of the load and of the jacket temperature. In this instance, then, there is no question that the poor economy with low jacket temperature should be attributed to the increased piston friction resulting from the higher viscosity of the oil on the cylinder walls, rather than to any change in fuel utilization.

As has been mentioned, the benefits of heating are most pronounced from the standpoint of acceleration. In making acceleration tests, a dynamometer load was selected to correspond to that of a car at about 45 m.p.h., the load decreasing with decrease in speed. With the dynamometer load set in this manner, the engine was idled and then the throttle suddenly opened. The inertia load of the inertia disc under these conditions corresponds to the inertia load of the car and the load-speed characteristics of the dynamometer approximate wind and frictional resistance of the car. Prior to each run, the engine was operated for a time at the constant speed of 650 r.p.m. and full throttle, to determine the fuel consumption under this load for the various carbureter settings used in the acceleration tests.

Typical time-speed curves are reproduced in Fig. 13. A mixture ratio of 9.4 to 1 at 650 r.p.m. and full throttle was used for runs Nos. 42 and 45 and no heat was supplied to the air entering the carbureter. Run No. 45 shows the acceleration from 800 r.p.m., while the unmarked curve at the right is typical of a badly loaded manifold. In a large number of tests, it was found that, with one exception, the richer the mixture is, the less is the time required for acceleration. Moreover, when additional heat was supplied to the intake air, the acceleration time decreased, regardless of the condition of manifold heating. The same acceleration time was obtained with a heated 15.3 to 1 mixture as with an unheated 9.4 to 1 mixture. As this represents a fuel saving of 60 per cent, there can be little argument as to the desirability of supplying adequate heat.

EFFECT OF HEAT ON MAXIMUM HORSEPOWER

This discusison would be incomplete without some reference to the effect of heat on the maximum power of the engine. Undue emphasis is frequently given to this phase of the problem and the fact that the engine is seldom operated for long periods at full load is overlooked. However, increasing the heat supplied the charge does decrease the maximum power of the engine, and it is usually the amount of this power that the manufacturer is willing to sacrifice to obtain good acceleration with an economical mixture that will determine just how much heating is employed.

To compare these tests with those made under different conditions, it may be essential to know just what intake temperatures were attained, how hot the hot-spot really was, the temperature of the exhaust gases, and the like. Such measurements were taken and Fig. 14 is a typical record. In one other direction, particular ef-

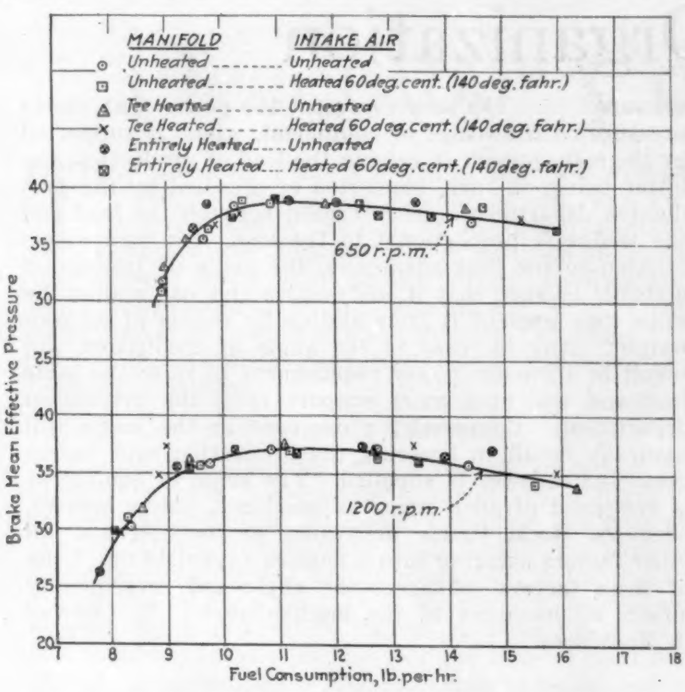


FIG. 11—CURVES SHOWING RESULTS OF TESTS MADE WITH THE THROTTLE HALF OPENED AT TWO DIFFERENT SPEEDS

fort was put forth to prevent the analysis of results being based too much on speculation and too little on knowledge. It would be unfortunate indeed to point out the benefits of a hot-spot manifold in vaporizing the liquid fuel that collects on the walls, without information as to where this liquid collected or as to whether it was thrown out of the air stream at all. Accordingly, prior to all of these runs, a preliminary series was conducted with a manifold having the tee section made of Pyrex glass. Motion pictures were taken, forming a permanent record of the observations. These testify to the existence of liquid in large amounts on the manifold walls and to the necessity for adequate charge heating.

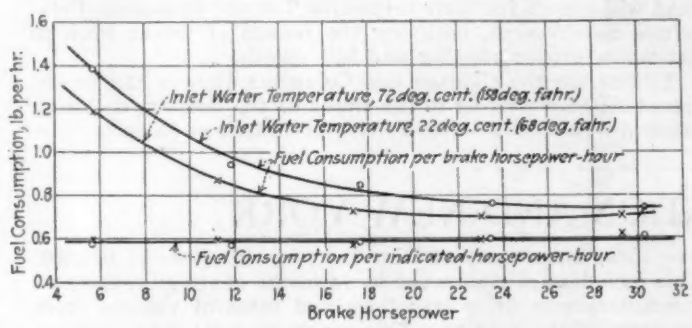


FIG. 12—CURVE SHOWING THE RELATION BETWEEN THE AMOUNT OF FUEL CONSUMED PER BRAKE HORSEPOWER HOUR AND INLET WATER TEMPERATURE

SUMMARY

In summarizing the question of fuel savings, the possibilities naturally divide into two distinct classes, as to what should be expected from the engine operator and what the engine operator should expect from the designer and the manufacturer. The engine operator should avoid unnecessarily rich mixtures by carefully adjusting the carbureter, giving particular attention to the starting and warming-up periods of the engine. In addition, he should not demand unreasonable acceleration. He then has the right to expect the manufacturers to supply him with an induction system that shall supply fuel and air in the proper proportions, distribute it equally to the different cylinders and heat it adequately. Not only has he the right to expect this, but if the past performance of the industry be any criterion, he is practically sure of getting it, eventually.

A discussion of fuel saving would not be complete without consideration of the effect of quality of engine fuel on economy. Within certain limits, it is possible to burn a wide variety of fuels in present equipment with some degree of satisfaction. So long as no preheating device is used, the ability to start cold demands a rather definite percentage of the lighter constituents. No radical changes in this respect can be expected so long as the average car must be started without preheating the charge before starting. On the other hand, there is no

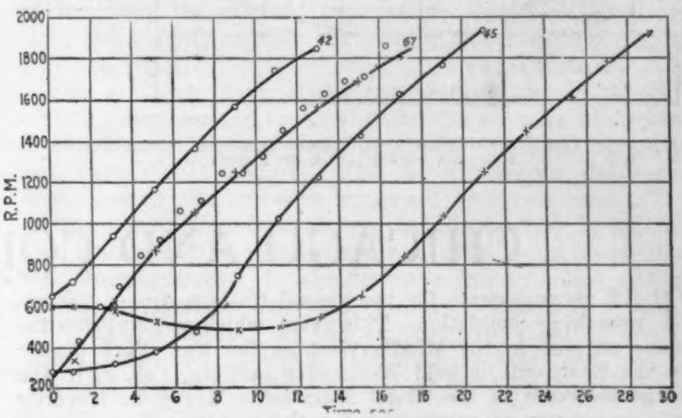


FIG. 13—TYPICAL TIME-SPEED CURVES

such definite and obvious limit to the addition of heavier constituents. There is no question whatever that increasing the end-point of fuels increases the fuel consumption in gallons per mile of the average car, for reasons which should be clear from the foregoing discussion, and this increase in specific consumption certainly becomes very rapid with an increasing end-point above about 400 deg. fahr.

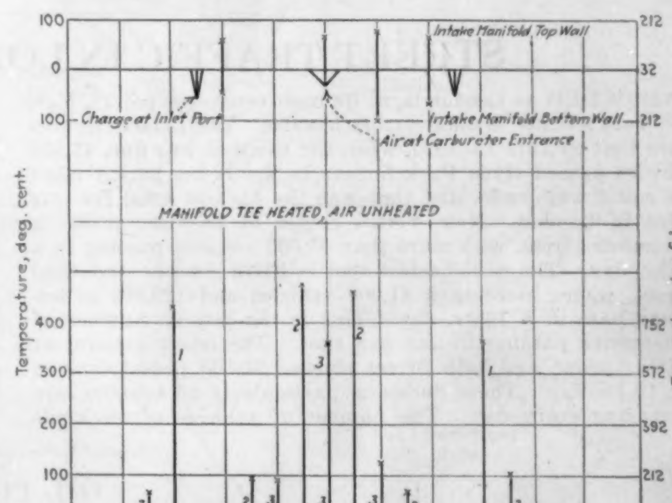
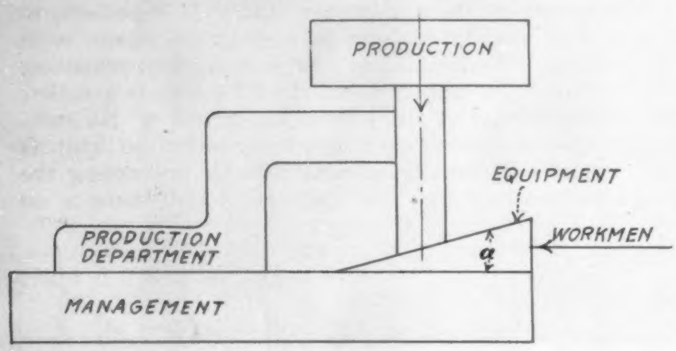


FIG. 14—CHART SHOWING THE TEMPERATURE DISTRIBUTION IN THE INLET MANIFOLD WALL AND IN THE EXHAUST GASES AROUND THE INLET MANIFOLD

Friction in Organization

IN the analogy between mechanical friction and friction in an organization, attention is directed to the accompanying diagram which shows graphically the application of this factor of friction to an industrial organization. The men represent the power that exerts pressure on the wedge of equipment, which is supported by the management in raising the load of production, the latter being, in turn, supported or steadied by the production department. The friction between the load and the wedge is proportional to the load. To utilize this friction to the best advantage, the angle of inclination *a* should be such that it will sustain the load and at the same time prevent it from sliding by reason of its own weight. Any increase in the angle of inclination will result in a greater power requirement to raise the same load and will need more support from the production department. Conversely, a decrease in the angle will naturally result in lowering the production rate, unless greater manpower is supplied. The angle of equipment is composed of such items as machines, prime movers, adequate stock, timely deliveries, cooperation and all other factors entering into a modern organization. Each of these factors influences the angle and consequently affects all members of the mechanism.—J. B. Conway in *Machinery*.



Graph of the Relation of the Elements of an Organization as Regards the Factor of Friction

CHICAGO AND COLUMBUS MEETINGS

THE arrangements for the annual Chicago dinner are approaching completion. This event, which accomplishes the same purpose in the Middle West as the New York dinner in the East, will be held Wednesday evening, Feb. 2, in the large ballroom of the Hotel Morrison. Harry L. Horning will be master of ceremonies for the evening; that assures plenty of hot-spots and general turbulence. A musical program of real merit under preparation by B. B. Ayers of the Meetings Committee promises to enliven things and add greatly to the evening's enjoyment.

The plans for the technical meetings call for a morning and an afternoon session, the motor truck and tractors being the principal topics for discussion. Many members have expressed interest in the engineering problems encountered by the men responsible for the maintenance and operation of large truck fleets and it is the intention that a valuable paper on this subject will be presented. The technical sessions also will be held in the Hotel Morrison.

The Columbus meeting and dinner will be held on Thursday, Feb. 10, during the week of the National Tractor Show. The dinner will be given at the Hotel Deshler. The location of the technical sessions will be announced in due course. Fred Glover will act as toastmaster at the dinner and E. A. Johnston will preside at the morning and afternoon technical sessions. Prof. O. W. Sjorgen of the University of Nebraska will present some constructive criticisms of present-day tractor design practice, based on the tests directed by him for the State of Nebraska. D. L. Arnold and John Mainland will report for their respective Tractor Standards Committee Subdivisions, outlining the results of recent work to determine proper plowing and belt speeds.

Tickets for the Chicago and Columbus dinners can be obtained now by writing to the offices of the Society, enclosing check to cover the number of tickets desired at $5 each.

STREET TRAFFIC IN LONDON AND NEW YORK

CROWDED as London is, at its most congested points, New York's traffic is undoubtedly heavier. The London figures show that on July 13, 1920, when the weather was fine, 43,505 vehicles passed Hyde Park Corner in the 12-hr. period when the count was made, and that was the highest total for any point in London. New York's center of heaviest traffic is Columbus Circle, with more than 50,000 vehicles passing in a 10-hr. day. The next busiest spot is Fifth Avenue and 42nd Street, where more than 41,000 vehicles and 129,903 pedestrians pass in a 10-hr. day. This is the largest number of pedestrians passing in any one spot. The latest account at Fifth Avenue and 34th Street showed 71,500 pedestrians in the 10-hr. day. These numbers, particularly of vehicles, are increasing every day. The number of vehicles of all kinds now using the streets of New York is very close to 400,000. This includes vehicles owned by residents of the city, those of commuters who drive into town and those of visitors from all parts of the country. This enormous total represents an increase of nearly 100,000 in the last year, and this increase has been caused largely by the expansion in the sale of small motor cars.

A comparison of the figures on street accidents will show that, in proportion to the population both the number of persons killed and the number injured are relatively about the same for London and New York. It is indisputable that most of the deaths are due to carelessness on the part of the persons killed.—Dr. J. A. Harriss in *The Evening Post.* (New York).

OIL POOLS

AN oil or gas pool or reservoir is not an underground cavern or "lake" filled with these products, but a porous rock body of sandstone, fissured limestone or other rock having continuous small openings and overlaid by shale, clay or other relatively impervious beds. These "cap rocks" are usually arched so as to entrap any oil or gas that seeps in, yet relatively tight areas in a given sand may surround a looser area of considerable magnitude, among the grains of which the oil is held until it is released by drilling operations. —C. T. Kirk in *Oil News*.

December Council Meeting

THE December Council Meeting, held in President Vincent's office at Detroit on the 4th, was well attended and a number of important subjects were discussed and disposed of. In addition to President Vincent, there were present First Vice-President Utz, Vice-Presidents Criqui, Martin and Wall, Councilors DeWaters, Germane and Johnston, Chairman Beecroft of the Meetings Committee, Joseph VanBlerck and Secretary Clarkson.

Financial Matters

Considerable attention was given to analyzing the financial reports made, these including, in addition to the regular statement of assets, liabilities and reserve, and of income and expense with budget comparison, complete detail figures on the operations of the Society during its last fiscal year, all of the items of income and expense being reduced to figures showing the relative loss or excess income per member per year in total procedure, by departments and according to each kind of work.

The balance sheet as at Sept. 30, 1920, showed that the net unexpended income for the fiscal year ended on that date was $19,556.12. This is about 7 per cent of the turnover, which was approximately $271,000. The total income for the last fiscal year was slightly in excess of $290,000.

The total income for the last fiscal year was $3,293.45 less and the total expense $22,849.57 less than had been contemplated by the budget. On Nov. 30, 1920, the Society had in hand Government and railroad bonds of a par value of $105,000, the purchase price of these having been $100,150.63; on the date mentioned their market value was $95,997. The total net assets of the Society on Oct. 31, 1920, amounted to over $200,000.

The accompanying diagrams show the proportional sources of income per dollar received and proportional expenditures per dollar expended by the Society in the last fiscal year; also the same information with respect to the total income and expense per member per year, the total income on this basis being $62.89 and the total expense $58.67.

The striking thing about the cost figures of the Society's operations is that, whereas the average of annual dues of members per year is $14.55, the cost per year per member is $58.67. The accompanying diagrams show clearly the relative expenses and revenues. The average initiation fee received by the Society is $22.05. The actual cost of inducting a new member is more than half this amount. It should be borne in mind and it cannot be ignored that the ratio of what each member pays to the Society to the expense per member consequent upon the Society's activities, is less than one to four. The cost of THE JOURNAL of the Society alone per

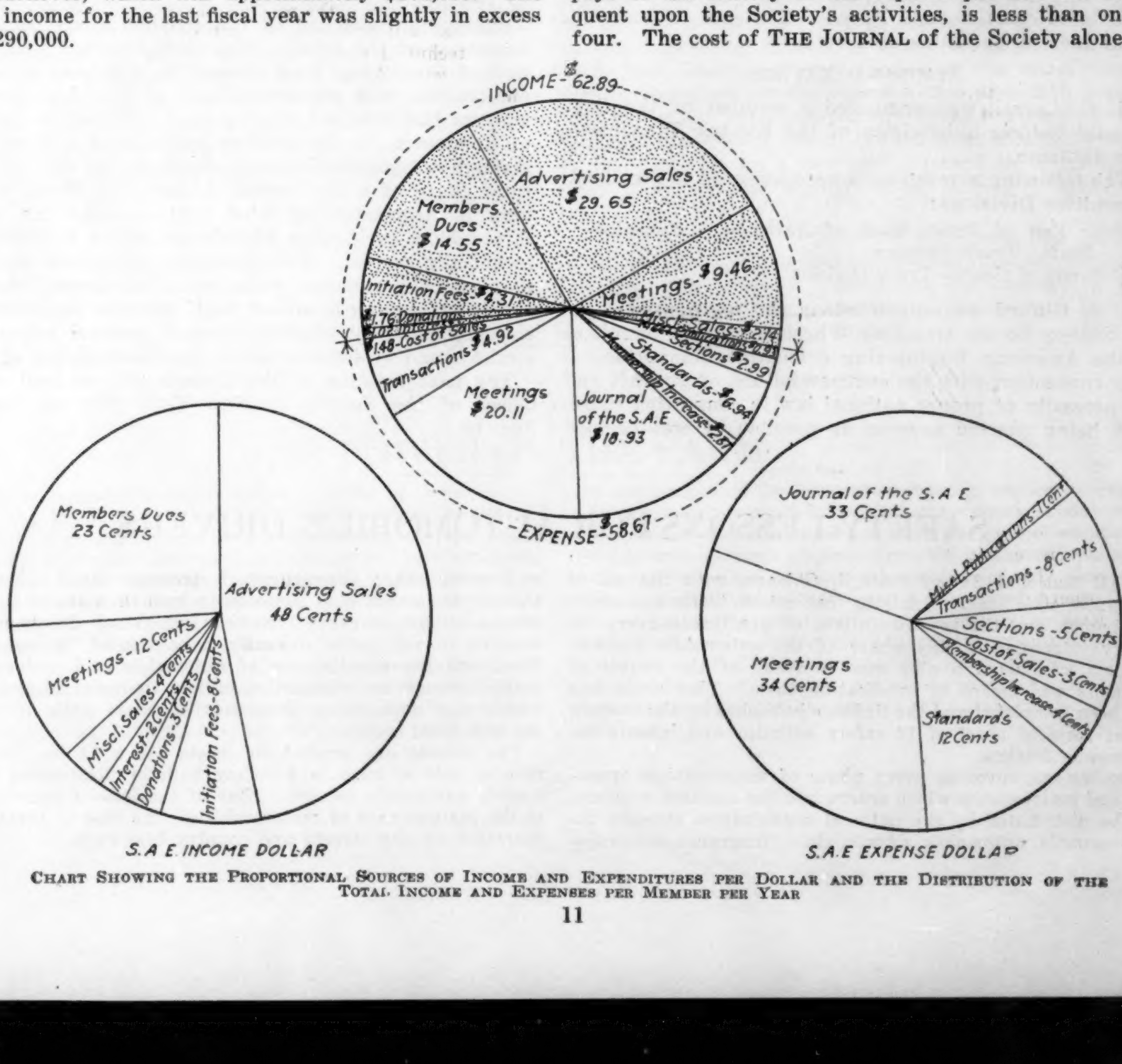


Chart Showing the Proportional Sources of Income and Expenditures per Dollar and the Distribution of the Total Income and Expenses per Member per Year

member per year is greater than the average annual dues. The same thing applies to the cost of the complete S. A. E. HANDBOOK.

In connection with the status of payment of accounts receivable by the Society, there is a noteworthy situation with regard to the annual dues. During the war the members paid their dues with about the same promptitude that they had paid them prior to the war. On Nov. 30, 1913, 55 per cent of the 1914 dues had been paid. On Nov. 30, 1920, 62 per cent of the 1921 dues had been paid. This is certainly very gratifying in view of current general financial conditions.

MEMBERSHIP

Two hundred and six applications were approved, 66 for Member, 4 for Service Member, 2 for Foreign Member, 81 for Associate, 49 for Junior, 1 for Affiliate grade of membership and 3 for Student Enrollment.

C. I. Bradley, F. I. Brown, F. C. Heath, E. H. Huesener, L. M. Klinedinst, N. B. Nelson, P. E. Norris, Joseph F. Sladky, S. W. Widney, H. R. Williams and Charles B. D. Wood were transferred from Associate to Member grade; R. W. Williams from Associate to Junior grade; and Foust Childers, L. A. Cummings, R. I. Dick, R. Karasinski, E. S. MacPherson, George J. Mead, Albert F. Miller, L. Ochtman, H. F. Peavey, W. H. Petit and A. F. H. Scott from Junior to Member grade.

One hundred and three applications for membership were received in November, as compared with 113 for the same month of 1919. On Nov. 30, 1920, there were 5230 on the rolls of the Society, including Affiliate Member Representatives and Enrolled Students, as compared with 4381 on the same date of 1919.

STANDARDS MATTERS

J. G. Carroll was appointed a member of the Commercial Vehicle Subdivision of the Electric Transportation Division.

The following new subjects were assigned to Standards Committee Divisions:

Rear End of Front Shaft of Three-Joint Propeller-Shaft—Truck Division
Differential Gears—Truck Division

A. J. Gifford was appointed as the representative of the Society on the Grinding Wheel Sectional Committee of the American Engineering Standards Committee.

In connection with the commercial use of aircraft and the necessity of proper national law in connection therewith being enacted as soon as possible, it was decided that the Aeronautic Division should be requested to formulate a special report, such as is provided for in the rules governing the Standards Committee, on regulations of commercial air navigation.

The Council confirmed the recommendation that the Society should organize jointly with the American Society of Mechanical Engineers, a Sectional Committee on Bolt, Nut and Rivet Proportions.

General Manager Clarkson was designated as the representative of the Society on the Executive Committee of the American Engineering Standards Committee.

The regulations governing the Standards Committee were revised in some minor respects. The complete regulations as now in effect will be included in the new edition of Vol. I of the S. A. E. HANDBOOK which is to be transmitted to the members at an early date.

SECTION AND SOCIETY MATTERS

The establishment of the Washington Section of the Society, in a reorganized form of the temporary organization authorized during the war, was approved.

After due consideration and discussion of the report of the Special Committee of the Council on the subject, the Council voted that the invitation to become a charter member of the Federated American Engineering Societies should not be accepted at this time.

It was formally determined that the Research Committee of the Society should be continued in reorganized form, superseding so far as shall prove feasible all previous committees appointed in the past for work related to research.

Discussion was had of the consideration that representatives of the Society office staff, together with members of the Society Fuel Committee, had been giving, in conjunction with representatives of the American Petroleum Institute and the National Automobile Chamber of Commerce, to the conduct publicly on a large scale through automobile dealers throughout the country or in some State of a Carbureter Adjustment Week, with a view to demonstrating what fuel economy can be attained by a carbureter adjustment which is considered technically correct. The consensus of opinion was that nothing of permanent value could be accomplished by such a proceeding in and of itself and that improved fuel economy must be attained through general educational methods and systematic policy in the servicing of cars.

The next meeting of the Council will be held at the offices of the Society in New York City on Monday Jan. 10.

SAFETY LESSONS FOR AUTOMOBILE DRIVERS

THE National Safety Council, Chicago, with the aid of automobile builders, driving instructors, traffic managers, repair-men and the representatives of practically every industry interested in any phase of the automobile accident problem, conducted a nine months study of the causes of accidents and means of eradicating them. This study has just been completed and the findings published by the Council in the form of a set of 12 safety bulletins and lessons for automobile drivers.

The lessons, covering every phase of motor-vehicle operation and maintenance which enters into the accident problem, will be distributed by the national organization through its local councils, automobile schools, clubs, insurance companies and every other channel which presents itself. For the Council feels that if it succeeds in making a set of the lessons available to every chauffeur and truck driver in the country it will mean annually a saving of thousands of lives, and the speeding up of automobile and motor-truck traffic through the elimination of lost time due to accidents which now amounts to thousands of hours daily in every big industrial center.

The lessons are printed on sheets 8½ x 11 in. On the reverse side of each is a safety bulletin illustrating some specific automobile hazard. Nine of the lessons are devoted to the maintenance of motor vehicles; the rest to their safe operation on city streets and country highways.

Pulitzer Trophy Race

THE race for the Pulitzer Trophy conducted by the Aero Club of America marks an epoch in the history of aviation. The winning of the race by an Army officer flying an American built airplane and the additional number of honors captured by American pilots flying American designed machines strike the highest note this country has contributed to aeronautics since the Wright Brothers wrought the miracle of the air at Kitty Hawk in 1908. Forty thousand people witnessed the race at Mitchel Field, Mineola, on Thanksgiving Day, and when Lieut. Corliss C. Moseley, driving his 600-hp. Verville Packard at an average speed of 3 miles per min. for the entire 132-mile course, made his smashing victory, the crowds became so wildly enthusiastic that they broke down the ropes and ran pell mell across the course to offer congratulations, despite the effort of the military police to restrain such a spontaneous demonstration.

Viewed from every aspect, the race stands prominently forth as one of the most successful aerial events ever held. The records made will not soon or easily be beaten, and happily of the total of 34 planes which made the start not one had a serious mishap, and not a single pilot suffered a serious injury. This means that the first of the Pulitzer races will mark the point in the history of aviation at which the public begins to realize that flying is, intrinsically, a safe means of locomotion provided the machines are properly built and driven by skilled pilots. It cannot but be a matter of immense satisfaction to the public at large that American machines gained so signal a victory over those of any other countries, and naturally the Army Air Service is not a little proud of the number of distinguished honors won by its officers and its airplanes.

Lieutenant Moseley's complete race record is as follows:

Lap	Time, min.	sec.
First	11	6.70
Second	11	0.37
Third	11	7.21
Fourth	11	15.32
TOTAL	44	29.57
Average Speed, m.p.h.		178

The achievement of Capt. H. E. Hartney, flying a Thomas-Morse 300-hp. Wright engine whose time was about 2 min. 30 sec. slower than Lieutenant Moseley's

THE 600-HP. VERVILLE PACKARD AIRPLANE WHICH WON THE PULITZER TROPHY RACE ON THANKSGIVING DAY AND MAINTAINED AN AVERAGE SPEED OF 178 M.P.H. FOR THE ENTIRE 132-MILE COURSE

was not less notable, his skilled driving of a "stock" plane eliciting the admiration of all aviators. Third prize went to Bert Acosta, one of the few civilian entries, flying the Italian Ansaldo S. V. A. with a 225-hp. engine while Lieut. St. Clair Streett, who commanded the Alaskan Flying Expedition, took fourth place with a 300-hp. plane.

It will be remembered that when Major Schroeder flew the Verville Packard in the International Race for the Gordon-Bennett Trophy at Etampes, France, last autumn, Lieutenant Moseley was his second pilot. In that event Sadi Lacointe won, establishing the world's race record, averaging for the course a rate of a little better than 169 m.p.h. for cross-country flying. Following the Gordon-Bennett race, one of the entrants, Count Bernard de Remenet, set up a new speed record by a straight-away flight at Buc Aerdrome by making a speed of 192 m.p.h.

While Lieutenant Moseley in no single lap of his flight in the Pulitzer event equalled the de Remenet straight-away speed of 192 m.p.h., his average of 178 for cross-country flying has Lacointe's average beaten, and so establishes a new world's race record.—Air Service News Letter.

POWER ON THE FARM

WE have people enough upon the farms of America today to make it impossible, at least within the life of the present generation, to have any shortage of food or to cut down materially our food exports or the raw products originating upon the farms, which go to manufacturers in American industry, if we can make farming a prosperous, contented, happy life and give to those young folks out on the farms the things which have been pulling them away from the farms and into the cities. There is nothing that will do that so quickly as the application of power to the farms, and there is nothing that will do it more rapidly than that wizard magic which has been invoked by the invention and the practical application of the internal-combustion engine. America in the next decade must intensify her production. She must produce more and more and yet more per unit of manpower and per unit of woman power upon the farms of this country to meet that which would otherwise be a very disastrous crisis. This will mean that upon the farms of America will go more gas engines until instead of 650,000 in the Mississippi Valley States, we will have 6,000,000, or two upon every farm, it will mean that instead of having about 450,000 tractors upon the farms of America, we will have about 2,000,000 or about 33 per cent of all the farms.—F. A. Odell in N. G. E. A. Bulletin.

Cleveland Tire Meeting

By Coker F. Clarkson

DURING the past 10 years over a score of standards relating to pneumatic and solid tires and rims therefor, as well as other closely related elements, have been established and reduced to practice with great benefit to tire manufacturers and dealers, automobile, truck and other automotive apparatus builders, and the users of rubber-tire-equipped automotive vehicles throughout the world.

Development of Tire Standards

This work was started by the Society of Automotive Engineers at the time the dimensions involved in the mounting of solid tires were standardized so that the tires produced by the various companies would interchange on the wheels with which motor trucks were regularly equipped. The next fundamental action of this phase of the work resulted in the establishment of four solid tire outside diameters as standard. Among the other important standards are deflection and set tests for pneumatic tire rims, pneumatic tire sizes, carrying-capacity tables for both pneumatic and solid tires and rim sections and contours for pneumatic tires. The organizations which, in addition to the Society, have taken part in the standardization proceedings, are the Tire and Rim Association (formerly the Clincher Automobile Tire Manufacturers Association, which was established for inspection work), the National Automobile Chamber of Commerce and the Rubber Association of America.

The principle upon which the tire standardization has been conducted is that tire products of different makers should interchange on the various automotive vehicles, that all structural elements of the equipment should be of adequate strength, and the lists of standard sizes not more extensive than necessary to meet clearly reasonable demands of design and operation, it being obvious that the fabrication and stocking of unnecessary sizes cause great economic waste.

Establishment of standards of this kind indicated is not easy. There is frequently lack of unanimity of opinion as to what should be done in a given matter, both among the tire manufacturers themselves and among the automotive vehicle builders, as well as at times between these two groups of "makers" and "users."

Genesis and Growth of Present Pneumatic Tire List

Fifteen years ago there was a demand which was entirely logical that the number of pneumatic tire sizes then being made should be reduced. The Mechanical Branch of the predecessor of the National Automobile Chamber of Commerce recommended a standard list of 10 tire sizes. Soon thereafter, however, the "oversizing" of tires came into vogue and the list of sizes again increased. Prior to that time pneumatic tires of different make would not interchange in rims therefor in general.

In 1915 a list of 18 pneumatic tire sizes was promulgated, nine of these being called "even sizes for regular equipment" and the others "odd or oversize tires" for purchase by car-owners only, that is not as original factory equipment. One of these sizes with its corresponding oversize was based on a 23-in. wheel or tire-seat diameter and two each on 24, 25, 26 and 27-in. wheel diameters.

In March, 1918, it was determined that all pneumatic tires, except the 30 x 3 and the 30 x 3½-in. sizes and their corresponding oversizes, should be of the straight side type. This left the number of "regulars" and oversizes at 18.

"War List"

In August, 1918, the 30 x 3, 32 x 4, 34 x 4, 36 x 4½, 36 x 5 and 38 x 5½-in. sizes were eliminated from the standard list, the 32 x 4 and 34 x 4 being replaced by the 33 x 4-in., the 36 x 4½ and 36 x 5 by the 36 x 6-in. and the 38 x 5½ by the 38 x 7-in. size. The 40 x 8-in. size was added at this time.

This reduced the total number of standard sizes to 10, seven of these being "regular" and three odd sizes as oversizes. Another important effect of this action was to eliminate the 26 and 27-in. wheel diameters, leaving one tire, the 30 x 3½ clincher, to be mounted on a 23-in. wheel, and three each on 24 and 25-in. wheels. This of course tended to reduce the number of wheel diameters in use from five to three.

Restoration and Addition of Sizes

In the next year, 1919, as a result of insistent demand from builders of certain types of car, the old 32 x 4-in. size and a new 32 x 4½-in. size were added to the standard list. The result of this, so far as wheel diameter is concerned, was the mounting of straight-side tires as follows:

Nominal Tire and Rim Size, in.	*Tire Seat Diameter, in.*
32 x 3½	25
32 x 4	24
33 x 4	25
32 x 4½	23
34 x 4½	25
36 x 6	24
38 x 7	24
40 x 8	24

This increased the total number of tire sizes, including the 30 x 3½ and 31 x 4-in. clinchers, to 13.

In March, 1920, the 33 x 4½-in. oversize was included in the list of regular sizes, as well as continued in the list of oversizes. A new regular size, 34 x 5 in., was added, this serving as an oversize for the 33 x 4½-in. size. In addition, the 42 x 9-in. size was included in the regular list, and as an oversize for the 40 x 8-in. size. This involved the use of wheel diameters as follows for straight-side types:

Nominal Tire and Rim Size, in.	*Tire Seat Diameter, in.*
32 x 3½	25
32 x 4	24
33 x 4	25
33 x 4½	24
32 x 4½	23
34 x 4½	25
34 x 5	24
36 x 6	24
38 x 7	24
40 x 8	24
42 x 9	24

This increased the total number of tire sizes, including the two clincher-type sizes to 15, 12 of which were in the regular series.

In August, 1920, the 42 x 9-in. size was replaced by the 44 x 10-in. size as a regular size. This made the total number of standard pneumatic tire sizes 16. In this connection it should be borne in mind that in the recent standard tables for pneumatic tires, the sizes for both passenger cars and motor trucks have been included. About 10 sizes, including two clinchers, are used extensively for passenger-car new equipment at this time.

Current Considerations

At a joint meeting of the Tire and Rim and the Truck Divisions of the Society held at Cleveland in November, with a number of passenger-car engineers and representatives of the National Automobile Chamber of Commerce, the Rubber Association of America, the Tire and Rim Association, the Motor Transport Corps and the Bureau of Standards in attendance, several important questions were considered, one main purpose being to coordinate the standardizing effort of the various interests involved, there having been controversy as to the manner of conducting the tire standardization work. At a recent meeting the Council of the Society reiterated the opinion that as a matter of principle designers of automotive apparatus should participate in the formulation of tire standards.

During the summer the Society had canvassed the industries involved on the proposal submitted to it for transmission to the vehicle builders, that the ultimate standard list of pneumatic-tire sizes should include only sizes mountable on the 24-in. wheel. J. E. Hale, of the Goodyear Tire & Rubber Co., which had advocated this proposal strongly, said at the Cleveland meeting that one tire diameter for each cross-sectional diameter of straight-side tire ought to be sufficient; that such practice would reduce the cost and improve the quality of tires, rims, wheels, axles, speedometers and other parts of cars; improve greatly distributing and stocking conditions, and result in tremendous economic saving to the industry as a whole and a saving in service to the consumer. He stated that the Goodyear company advocates having tire sizes that all fit one rim diameter, because it is desirable to oversize right through the line of tires.

In opposing the proposal, J. C. Tuttle of the Firestone Tire & Rubber Co. referred to the changes that had to be made in the list of standard pneumatic-tire sizes that had been promulgated during the war.

G. P. Dorris made a strong plea for the retention of the 33 x 5-in. tire.

Past-President Marmon addressed the meeting on behalf of the Cole, National and Premier companies, as well as his own company. He expressed the view that standardizing on the 24-in.-wheel series of tire sizes would handicap engineering effort and impede the development of cars of greatest economy from the standpoint of maintenance.

W. H. Allen of the B. F. Goodrich Co. stated that the tire industry is opposed to the 24-in. wheel plan. He questioned the wisdom of considering pneumatic tires jointly for passenger cars and trucks, feeling that truck-tire practice may change considerably.

Practically all of the pneumatic tires used on trucks are mounted on 24-in. wheels. F. A. Whitten of the General Motors Co. said that the truck builders favor conditions that permit oversizing of tires without difficulty.

The following resolutions were passed at the meeting in connection with the standard list of pneumatic-tire sizes:

> The 24-in. wheel is not the only desirable one to use, and the present standard of pneumatic tire and rim sizes is satisfactory.
>
> A small committee, composed of tire, motor truck and passenger-car members, should be appointed to investigate the problem of reducing the number of standard sizes of pneumatic tire to the lowest possible minimum, with a view to presenting the facts to the National Automobile Chamber of Commerce, the Rubber Association of America and any other interested body, and requesting specifically that these bodies take the matter up from the commercial point of view.

While these resolutions had, so far as committing the Society under its rules of procedure in standards matters is concerned, only the status of straw votes, the Council of the Society at its meeting held last month appointed, in response to the passage of the resolutions, the following committee:

J. G. Vincent, President of the Society (Chairman)
H. H. Rice, Chairman National Automobile Chamber of Commerce Tire Committee
A. L. Viles, General Manager of Rubber Association of America

Limits for Oversize Tires

The executive committee of the Tire Manufacturers' Division of the Rubber Association recommended in September last that the actual cross-sectional width of pneumatic cord tires when inflated in accordance with the S. A. E. Standard be not less than the nominal width marked thereon or greater than 10 per cent in excess of such nominal width; it being understood that the nominal width of the so-called 5-in. tire shall, in accordance with custom, be considered 5¼-in.

It is considered very important that limits should be prescribed for the actual outside diameters of the respective nominally dimensioned tires, as affecting gear ratios, speedometers, body and fender clearances, vehicle turning radius, brackets for spare tires and the use of non-skid devices. Granting that the tire manufacturers or a large proportion of them will follow the Rubber Association recommendation as to dimensional limits of tire cross-sectional width, it is apparent that the only way the actual outside diameter can be controlled is by limiting the amount of tread placed by the tire manufacturers on carcasses of given sizes.

Metric Sizes

For several years the desirability has been appreciated of having lists of reasonable length for metric sizes of pneumatic and solid tires for export. The question is one of feasibility and practicability. The Society is now interchanging data with foreign organizations. The subject is one in which commercial as opposed to engineering considerations are largely the determining factors. Sales matters have much weight, of course, in all of the tire standardization work; which is one and probably the greatest reason for the difficulty and complexity of it. The above named committee will take under advisement the problem of the metric tire sizes.

Interchanging Front and Rear Pneumatic Tires on Trucks

With the increasing use of pneumatic tires on motor trucks has come the problem of obviating the necessity of carrying more than one spare rim and tire for use in case of tire change on the road. This problem has assumed serious proportions on account of the lack of

interchangeability of rims and tires as between front and rear wheels. The truck industry requested the Society to investigate the situation and accomplish standardization permitting interchanging 36 x 6, 37 x 8 and 40 x 8-n. rims and tires between front and rear wheels. The metal wheel manufacturers also have indicated their interest in the matter. The subject was discussed at the last meeting of the Society and a special meeting of the Tire and Rim Division was held to consider possible means of securing the desired interchangeability. The members discussed several suggestions, one of which was to use two adapter rings, one for the normal-size rim on a wheel and the other for the oversize rim on the same wheel. This was not considered advisable, however, in part because of the possibility of double oversizing tires which is not approved by the tire manufacturers for truck work.

The tire industry felt that truck design should be further investigated with a view to securing more even distribution of weight between the front and rear wheels, to permit the development of a suitable rim for interchangeability of tires between front and rear wheels without the necessity of carrying additional spare parts to those currently used on the truck. It was decided, however, to attempt to lay out a single set of wheel rim or felloe dimensions for the 5, 6, 7 and 8-in. tires.

The truck engineers were canvassed on the truck weight-distribution question, but the great majority of those replying were decidedly averse to considering seriously much modification of present practice in this respect.

At the Cleveland meeting George L. Lavery of the West Steel Castings Co., submitted for consideration sketches of construction for use in emergency interchange of 6, 7 and 8-in. tires, eliminating adapter rings. The sketches met with some favor and were studied in revised form at the meeting of the Truck Division held on the day following the general tire conference.

HIGHWAY RESEARCH

THE following national organizations have been asked to appoint representatives on the Advisory Board on Highway Research of the National Research Council:

- American Association of State Geologists
- American Association of State Highway Officials
- American Institute of Consulting Engineers
- American Automobile Association
- American Concrete Institute
- American Railway Engineering Association
- American Society for Testing Materials
- American Society of Civil Engineers
- American Society of Mechanical Engineers
- American Society of Municipal Improvements
- Bureau of Public Roads, Department of Agriculture
- Division of Geology and Geography of National Research Council
- Federal Highway Council
- National Automobile Chamber of Commerce
- National Highway Traffic Association
- Society of Automotive Engineers
- University Highway Engineering Departments
- War Department
- Western Society of Engineers

There is urgent need for a systematic, thorough, comprehensive research program that will place our road building on a sound scientific engineering basis and enable the country to spend effectively the large sums involved. The need is realized in many quarters and several agencies are at work; but their work is uncoordinated, incomplete and overlapping. To secure cooperation of the numerous existing agencies and through such cooperation bring about the concentration of the talent of the country and avoid duplication, a conference was called recently. It is the intention to secure a definite assignment by Congress of a certain portion of the unexpended balance of Federal-aid road money to some agency that will administer the funds under the direction of the Advisory Board. It is hoped that sufficient funds will be made available immediately to allow the research work to begin.

AMERICAN MERCHANT MARINE

THE American carrying trade to and from United States ports showed a steady increase in tonnage for the fiscal year ended June 30, 1920, but, during the same period foreign carrying trade to and from our ports increased at a more rapid rate than our own trade, with the result that American ships in July carried less than 50 per cent of our total foreign commerce. American ships carried about 57 per cent of our July trade with North America, about 55 per cent of our trade with South America, and less than 30 per cent of our trade with Europe.

The way has been opened for increasing the importance of the United States as a maritime nation. For 60 years a large proportion of the profits of American industries has gone overseas in the form of ocean freight charges, marine insurance premiums and banking commissions, and the toll has aggregated billions of dollars. From 1870 to 1890 alone, foreign ship owners collected more than $3,000,000,000 from us. In the fiscal year which closed shortly before the war the bill amounted to nearly $400,000,000, and last year, it is estimated, this country paid an amount exceeding $700,000,000 to enrich our competitors on the high seas.—Guaranty Trust Co.

DETROIT HOUSE NUMBERS CHANGED

IN connection with the renumbering of the houses in the delivery area served by the Detroit post office which became effective Jan. 1, the records of the Society have been corrected to show these new numbers. Members of the Society located in Detroit, Highland Park and Hamtramck are urged to inform the office of the Society in New York City promptly of all instances where communications are delayed in delivery by reason of their being addressed to old house numbers. It is only by the cooperation of all of our members that it is possible for the Society to maintain accurate records. The membership at large and especially those residing at Detroit and in the immediate vicinity are requested to send in all changes of addresses promptly to the headquarters of the Society at New York City.

Impact Tests on Trucks

By E. B. Smith[1]

Semi-Annual Meeting Paper

THE United States Bureau of Public Roads has recently started an elaborate investigation of soils as related to road construction. This investigation will extend over considerable time and cover a large part of the United States, taking into account all kinds of soil and road conditions. We are also investigating the forces which tend to break up and destroy roads.

The most destructive force received by a road is that of impact. For the past year we have been studying this force, but have been delayed by weather conditions many times. In the beginning, we found it necessary to develop means of measuring impact forces. This was done by receiving the impact on a small copper cylinder and measuring the deformation of the cylinder. Then, any impact force that would produce the same deformation in the copper cylinder can be stated in terms of the equivalent static force. This is somewhat approximate, but is a proper comparison within certain limits. Even when we know what static or equivalent force produces the same deformation in a copper cylinder, this does not tell the whole story because an impact force is much localized and produces shattering effects. The copper cylinders for measuring this force are all carefully heat-treated for uniformity and calibrated for static deformations so that, after the impact has been received on the copper cylinder we determine its static equivalent approximately. An apparatus is being developed which is to be installed on a truck or an automobile. Then, if the truck so equipped is run over any type of road under any given speed and load conditions, we can obtain the impact values, which will enable us to pick out the conditions which give us the destructive impact values. The impact values we have secured will run as high as 43,000 lb. If we imagine a road able to withstand such an impact for any length of time, it would probably be one of very thick reinforced concrete.

These impact values are largely dependent upon the type and construction of the truck. Unsprung weights have a great influence upon the impact value of the blow on the road surface and a reverse influence upon the body of the truck, as perhaps may be felt by the cargo or by a passenger. Those effects are in two different directions. Our present aim is to investigate this impact and the effect of the unsprung weight on the road. The impact force, as received from the unsprung weight, is a result of the acceleration due to gravity and to the pressure or kick of the spring. It may be seen readily that the product of mass times the acceleration gives a maximum impact force when the mass of the unsprung weight is the greatest. If two masses are taken, one supported on top of the spring and the other below the spring, and dropped from a height of several feet, the resulting impact as it strikes the pavement will be comparatively small; that is, small in comparison to a case where that same combination is dropped from a small height of 2 or 3 in., this combination being released from a support under the spring in either case, thus allowing the spring to kick downward. The resulting impact blow would be much greater in the latter than in the former case.

Most of the tests have been made on solid tires. A few have been made on worn solid tires and some on pneumatics. There is a large difference in the impact value of a new and an old solid tire. The impact value for old and badly worn solid tires increases as much as 45 to 75 per cent. The impact is greatly reduced by the use of pneumatic tires. I shall not discuss the advantages or disadvantages of pneumatic tires from a construction standpoint, but as regards their use for protecting roads it seems that pneumatic tires are certainly very much to be preferred to any other type of tire. It is our intention to elaborate upon all of these tests. We expect to include in the tests different types of pneumatic tire and different unsprung weights and to investigate some of the special wheels, such as cushion or spring wheels.

The road engineer is able to build an excellent road if he has proper funds and materials, but it should be the duty of automotive engineers to design trucks so that the road engineer can build economically a road that will stand the loads and punishment of truck traffic, without undue expense. It would be very helpful to the road engineering profession if the representatives of this Society would make it their duty to watch road conditions, to aid the road engineer in governing the forces that are being applied to roads and to help create a sentiment that would discourage the abuse of roads.

[1]Senior testing engineer, Bureau of Public Roads, Department of Agriculture, Washington.

WATER POWER

IN the West, where 70 per cent of the water power of this country lies, water power is known and appreciated. Here in the East we have a different problem. Conservation here must come by the development of such water powers as we have and combining them with steam plants economically operated and the product turned into a great trunk line system which will furnish power for the whole manufacturing district or zone. Twenty-five years will see the elimination of steam power in the zone from Boston to Washington and for 150 miles inland from the coast. Only by such a twentieth century method of furnishing power by wholesale can the manufacturers of this zone hope to compete with those of Europe and other countries where water power development is being rushed to conserve exhaustible fuel supplies.—*Bulletin of the Water Power League of America.*

FARM AND COMMUNITY

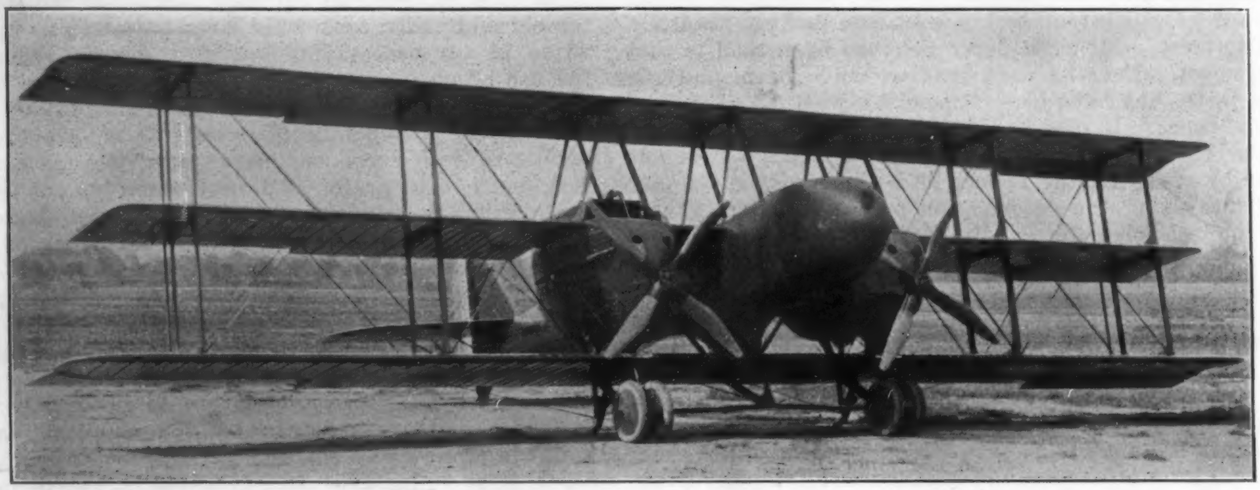
THE value of farm property is 51 per cent of all the property of industry in our entire country, approximating $51,000,000,000. The unit which affects the lives of the people most directly is not the state, nor the county, nor the city. It is the community. This unit is described by lines within which people are associated together for material and social welfare. That unit developed out of the needs of the times, when originally the farmer tilled the soil.—Governor S. R. McKelvie.

Recent Advances in Aviation

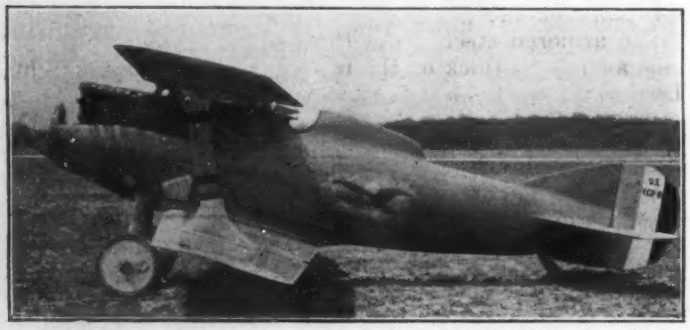
By Col. Thurman H. Bane,[1] U. S. A.

Semi-Annual Meeting Address — *Illustrated with* Photographs

THE object of my remarks is merely to familiarize you with some of the Air Service work that we have been doing at McCook Field. The Air Service was known as the Aviation Section of the Signal Corps before the war. It became too large to be a section of the Signal Corps; so, during the war there was a temporary organization known as the Air Service which was divided into a Bureau of Aircraft Production and a Department of Military Aeronautics. Later these were united under one head and there was a Director of the Air Service. But the Air Service, up to June 4, 1920, was a temporary organization and not a part of the Army. Unless the Army reorganization bill had been passed on June 4 the Air Service would have reverted, July 1, to the Aviation Section of the Signal Corps, which we would have considered a calamity. This bill now makes the Air Service a branch of the Army co-ordinate with the infantry, cavalry, field artillery and coast artillery. The Air Service is the third branch in size in the Army. The first branch is the infantry, then comes the field artillery. We feel that we are now on a more or less stable basis as a part of the Army.



The Lepere Reconnoissance Triplane



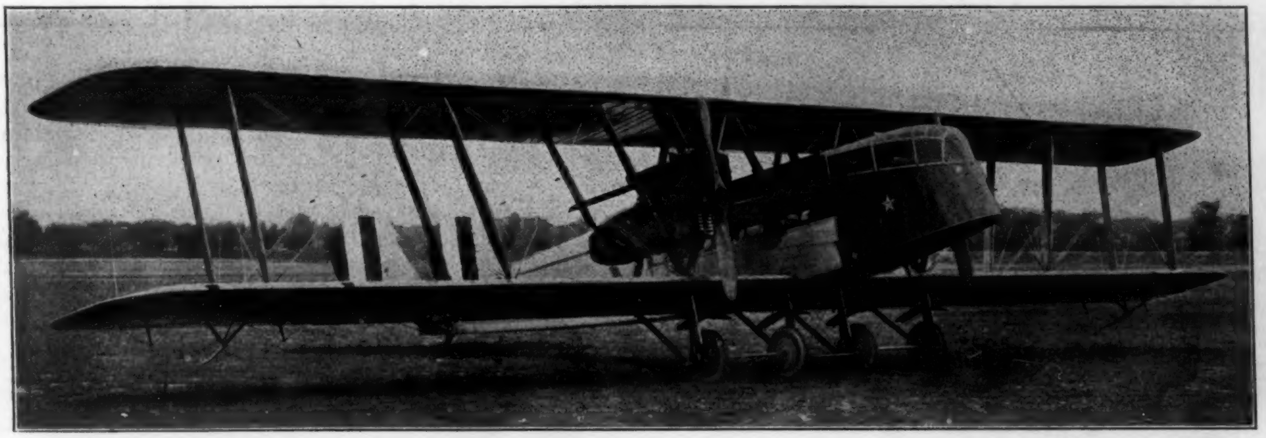
Verville Single-Seater Airplane Which Was Entered by the Air Service in the Gordon-Bennett Race

You are all probably familiar with the fight that has been raging for the last year for a separate Air Service. Most of us who fly, and who have been in this service since before the war, feel that the Air Service is a specialty that should not be developed as part of some other service. The development of it should not be entrusted to the Army and the Navy, not because we think they are not capable of handling it, but because we think they are basicly interested in other things and that the development of the air should be given to a separate organization. The Army and the Navy would undoubtedly develop observation aviation for their own uses, but that cannot be developed without pursuit and attack aviation. Pursuit aviation is where the individual in one plane very rapidly climbs at high speed, flies off by himself looking for trouble and drives the enemy out of the air. The two-seater observation airplanes could not be operated over a fleet, for example, unless the air could first be cleared of the enemy's pursuit aircraft, because they would be attacked and brought down. We feel that the pursuit and attack aviation should be developed by a separate branch of the service. I think that some day, perhaps, we will have such an organization. As it stands now, we are much better off than we ever have been; that is, we are a coordinated branch of the Army and are commissioned permanently in the Air Service.

Airplanes Developed During the War

The pursuit airplane developed by the Air Service is a Thomas Morse design with a speed of about 150 m.p.h. It can climb to a 20,000-ft. altitude in 20 min. It is very maneuverable, snappy and a single-seater. The aviator goes up alone, looking for trouble. Another type of pursuit airplane, made by the Ordnance Engineering Corporation, has about the same speed and climbing ability. Fifty of each are being put into production now. The Loening monoplane, developed during the war, is now being built by Mr. Loening. We have also an airplane in which we are now mounting a large engine for the purpose of competing for the Gordon-Bennett cup in France. This airplane will have a new 600-hp. engine and is expected to develop a ground speed of 185 m.p.h.

[1] M. S. A. E.—Chief of engineering division, Air Service, Dayton, Ohio.

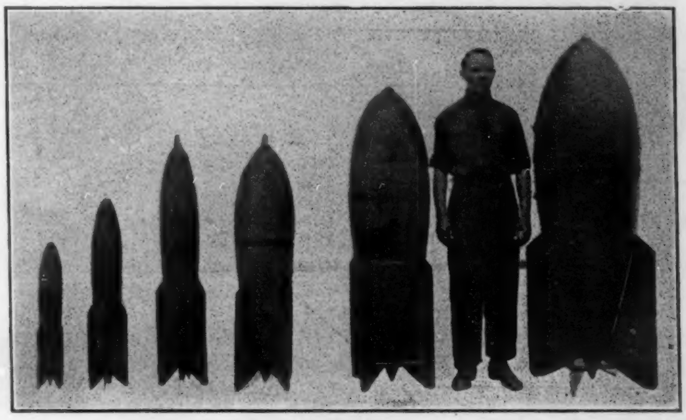


Martin Day Bombing Plane Converted for Commercial Purposes

The DH-4 originally had the gasoline tank between the observer and the pilot. In the observation airplane, there should be good communication between the observer and the pilot. An observation airplane is used for flying over the enemy's lines and spotting artillery work.

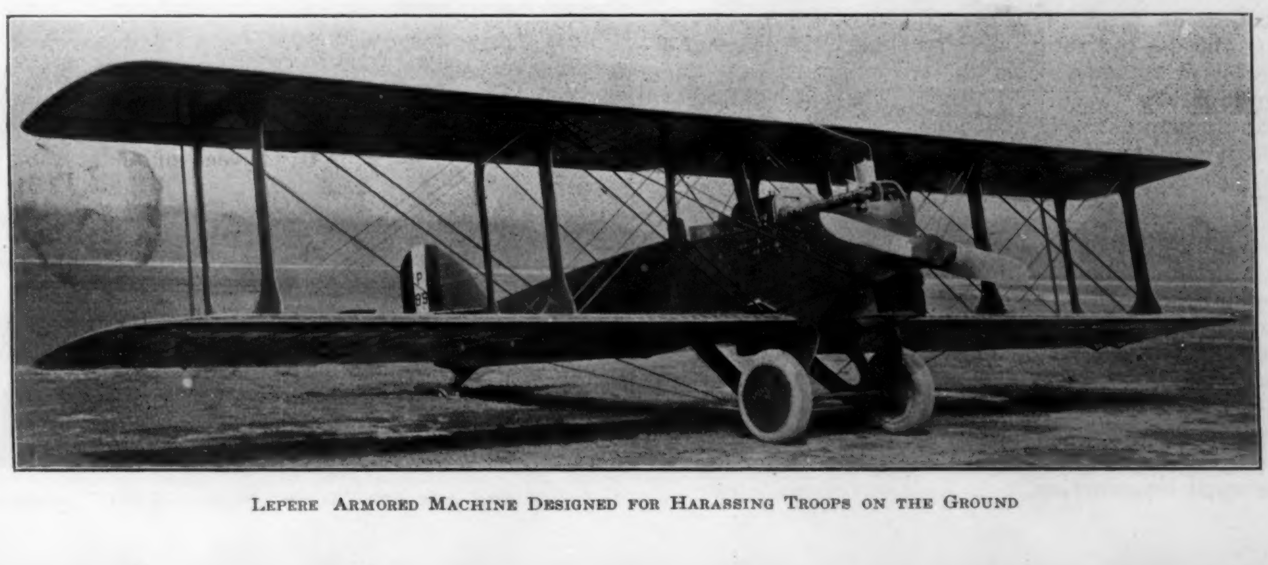
The XB-1A machine was started by President Vincent during the war. We are now having about 40 built for use on the Mexican Border. We are now patrolling the Mexican Border every day from Brownsville to San Diego. The Lepere triplane, built by the Packard Motor Car Co. during the war, is a very interesting type. It was far ahead of its time and was built and known as a surveillance airplane, for long-distance observation, to find out what the enemy does back of his lines. This plane flies high and for a long distance; it is a triplane, and has two Liberty engines on each side. The U S D-9A was built as a day bombardment machine. It carries 500 lb. of bombs under its wings and can reach an altitude of about 14,000 ft.

The short-distance night-bombardment airplane was built by the Martin company at Cleveland, during the war. We are building now 20 modified planes equipped with superchargers, so that they can climb much higher. The Martin bomber can carry a load of 500 lb. of bombs. These are controlled by the bomber, who rides in the nose of the machine. Through a glass he can see out to get his lead on the thing he intends to drop the bombs on. By a device like a typewriter, he can then select the bombs he wishes to drop and drop them from one side or the other, or all at once. The bombs that we now use weigh 25, 50, 100, 250, 500 and 1000 lb. We are now designing a 2000-lb. bomb. I suppose there is no limit to how large they may become; the tendency is to make them larger. Bombs also are carried inside an airplane with a trap inside of the fuselage.



Types of Bombs

We have an airplane that is built to fly low and shoot at troops on the ground which carries a 37-mm. cannon in an armored steel turret that is 3/16 in. thick on the side and 1/4 in. thick on the bottom. It also carries eight Lewis machine-guns. A 37-mm. cannon can be mounted on a Martin bomber. It fires a sensitive high-explosive shell that will go off upon hitting the fabric of another airplane.



Lepere Armored Machine Designed for Harassing Troops on the Ground

THE FOKKER AIRPLANE

In the training plane built by Mr. Vought, of New York City, there is a hole in the upper wing so that in case of a wreck, the man in the front seat can climb out with a parachute on his back.

The German Fokker has a thick wing section; one strut and no wiring. It can be set up completely in about 20 min. The fuselage is constructed entirely of steel tubing welded at the joints. The wings are made of wood, in thick sections. We have learned much from the German Fokker. It is not very fast; our own machines are much faster. The Fokker makes about 115 m.p.h., but it is snappy and maneuverable. The engine-bed mounting is also made of steel tubing.

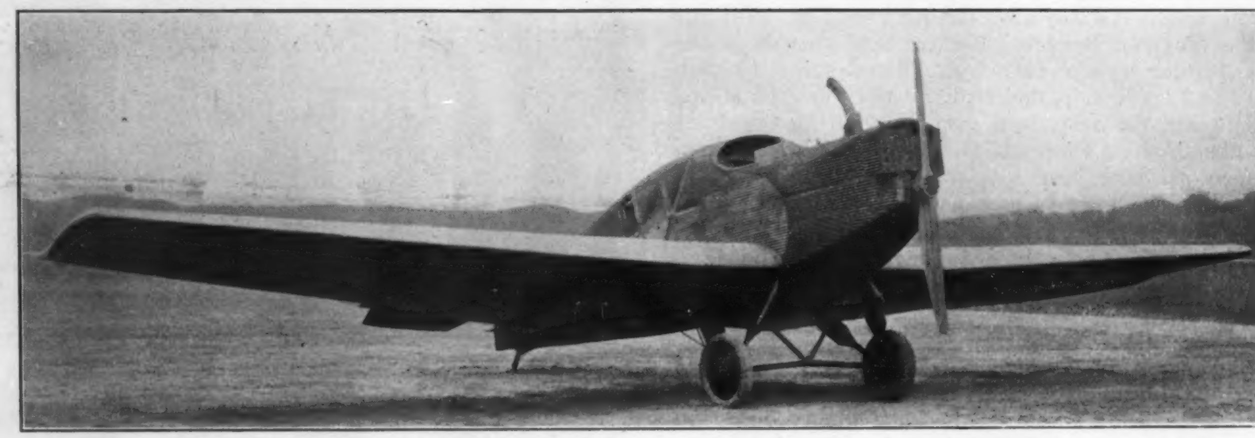
The German Roland is a very interesting type. It is made of ship-lap boarding and is very much the shape of a fish. It is a very nice-looking, streamline airplane and flies even better than the Fokker. The much-talked-of German Junker has a section about 2 ft. thick; it is a single-wing monoplane. Several of these are being operated as passenger ships in New York City and hold about eight people each.

The military Junker used at the battle front was a very interesting type and was the forerunner of the present commercial airplane. This is made of sheet aluminum, corrugated on the fuselage. The great advantage of this is that it can be left out in the weather, hangars are not necessary and the fire risk is practically eliminated. The Breguet is an interesting type of French construction. We are going thoroughly into metal construction in this country and I believe that in a short time it will entirely replace wood construction.

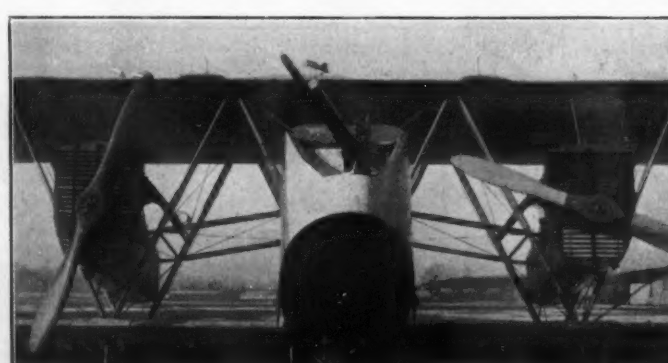
In reference to commercial aviation, we have the Martin bomber in which the fuselage is slightly modified so as to carry 12 passengers. The military value of this is evident. Passenger airplanes could be built so that they could be modified in time of war and made into bombing airplanes. This is an excellent airplane and flies very comfortably. It was built during the war to demonstrate that troops could be carried. The interior of the airplane is fitted with seats. I had the pleasure of flying this ship to Dayton from Indianapolis recently. It flies as well and as comfortably as any small airplane.

ENGINES

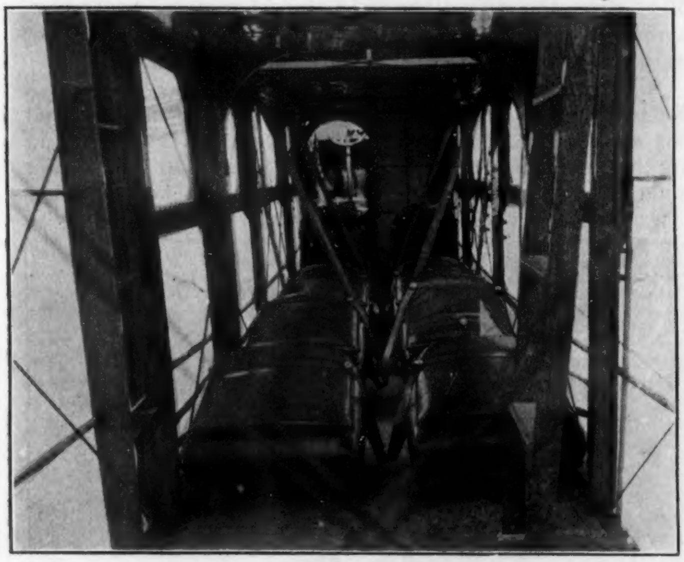
The Packard eight-cylinder engine of about 160 hp. was built this year. The Packard company built a series of three engines, an eight-cylinder, a small 12-cylinder of about 300 hp. and a large 12-cylinder which we hope will develop about 600 hp. The eight-cylinder engine has a carbureter on the bottom and the manifold goes up through the crankcase. Everything in this engine is accessible. In the small 12-cylinder engine the carbureter is also at the bottom. President Vincent, in this engine, has shown the advantage there is in having a designer learn to fly. We feel that a designer ought to know how to fly, as an aid to careful design. In the large 12-cylinder engine everything is also accessible. It is the same type of engine exactly and it shows a big improvement over the Liberty. The Liberty engine has the carbureter inside the V and the Packard large 12-cylinder



THE JUNKERS ALL-METAL INTERNALLY TRUSSED MONOPLANE



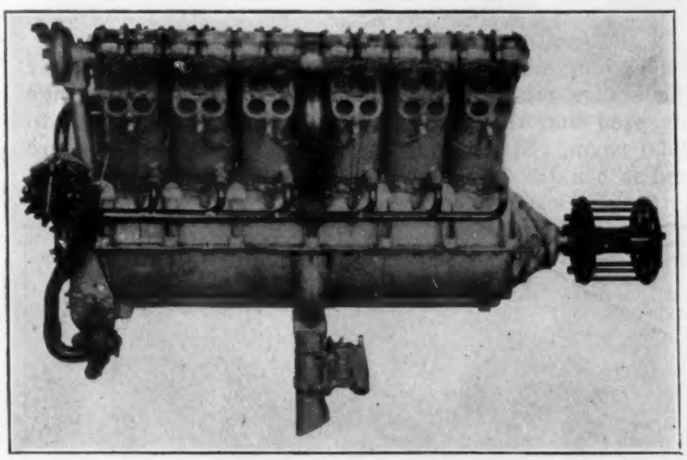
THE MARTIN AIRPLANE EQUIPPED WITH A 37-MM. CANNON



The Interior of the Martin Commercial Biplane Showing Passenger Compartment

engine has the carbureter underneath. The distributers are at the side, where they are accessible; on the Liberty engine the distributer is up against the fire wall.

I do not mean to detract from the evident merits of the Liberty engine. Men who fly and use the Liberty engine say that the Liberty-propelled planes are the most satisfactory and reliable aircraft we have ever had. A 650 to 700-hp. engine is now being built. It is an 18-cylinder engine in three banks. We hope to develop

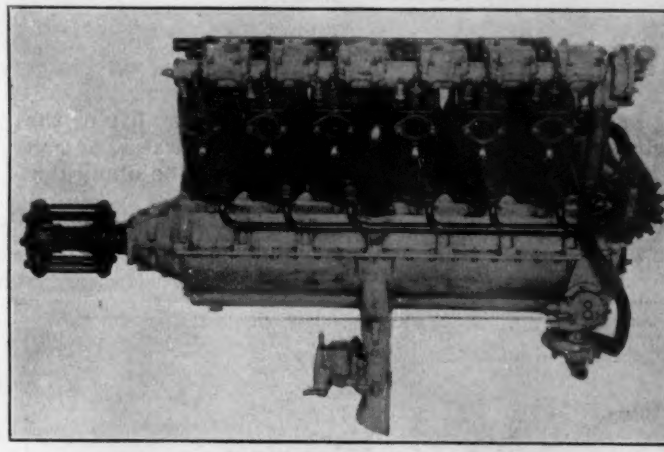


The Packard 12-Cylinder Aircraft Engine Equipped with Four Valves Per Cylinder

something out of it. It has a 5½-in. bore, a 6½-in. stroke and weighs about 2.2 lb. per hp. It is a step forward if high power is required. It has three magnetos. Everything is interchangeable. Any manifold can go any place; they are all alike. The same is true with the water manifolds.

A single-cylinder flexible laboratory engine, which is illustrated on page 22, is being built so that any reasonable-sized cylinder can be put in and any desired bore or stroke used. It is valuable for testing either air-cooled or water-cooled cylinders. An adjustable part in the center can be moved to get any desired length of stroke. It is a clever job and works out wonderfully well. We have supplied drawings to several manufacturers who are making them up for test purposes. The standard 300-hp. Hispano-Suiza engine is the best for pursuit purposes and we are supplying them in all pursuit airplanes.

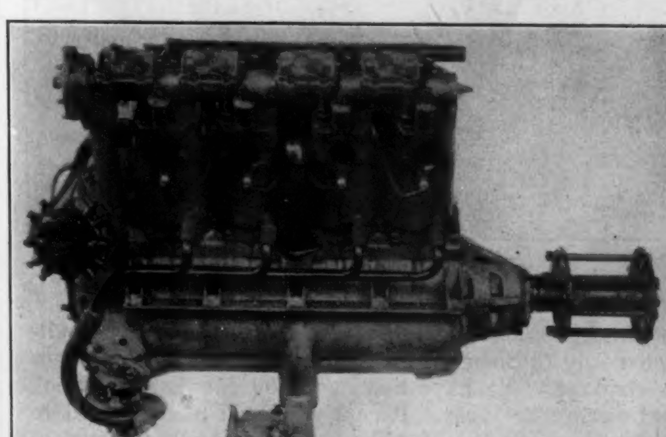
The Cannon Hispano engine of 300 hp. is provided with a 37-mm. automatic cannon, as shown on page 22. The engine is geared so that the cannon shoots through the propeller shaft. The crankcase differs from the ordinary construction, being split in a vertical plane. The nose of the cannon comes out through the propeller hub. The carbureter is underneath. The A.B.C. Dragon-Fly engine, which is illustrated on page 22, is supposed to develop 320 hp. We actually developed about 270 hp. with it. It is an air-cooled engine. We let several contracts this year for other air-cooled engines. We feel the air-cooled engine may be a very desirable engine for pursuit purposes. The J. W. Smith air-cooled engine, which is built in Pittsburgh, has a four-point cooling system in which air is projected on four points of the



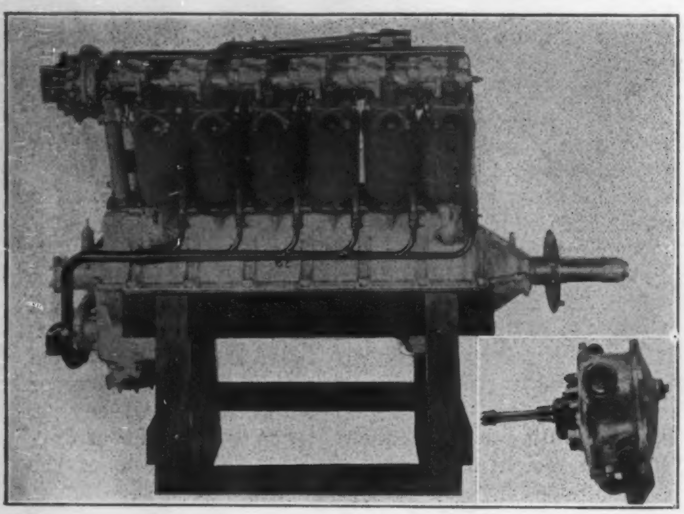
The Standard 12-Cylinder Packard Aircraft Engine

cylinder. No air gets to the back of a cylinder in an ordinary air-cooled engine. A front view of the Smith engine is given on page 23.

We introduced an oil cleaner in the Liberty engine oil-pump. It is a small bucket something like that on a centrifugal separator, which throws the dirt out of the oil. The bucket whirls at high speed and throws all the dirt out. We ran an engine equipped with this device for about an hour and got a spoonful of Babbitt metal and refuse out. This oil cleaner assures us that the



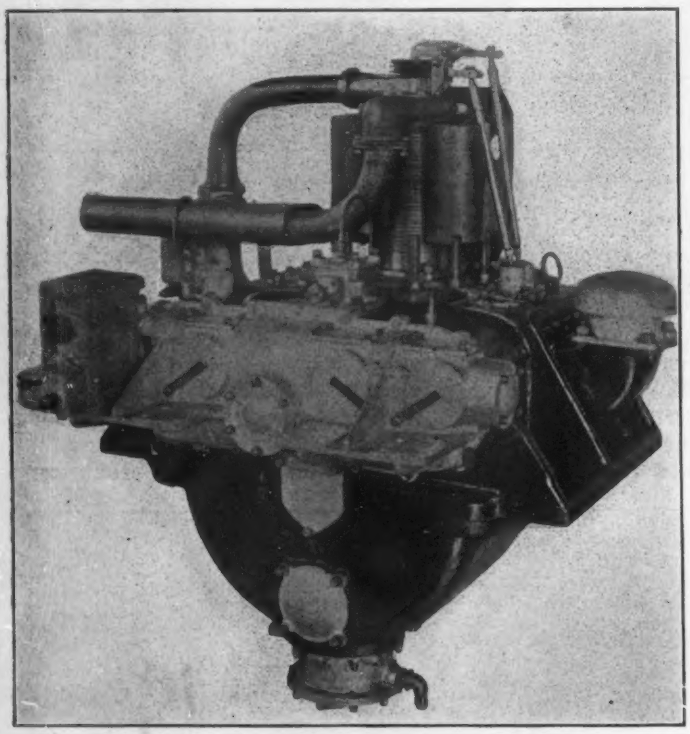
Side View of the Standard Eight-Cylinder Packard Aircraft Engine



LIBERTY 12-CYLINDER AIRCRAFT ENGINE, THE CENTRIFUGAL OIL CLEANER WHICH WAS DEVELOPED BEING SHOWN IN THE INSERT

engine will always be clean. It lengthens the life of the engine very materially. It is a simple apparatus, as can be seen from the illustration and ought to be applicable to automobile engines.

We have a very light parachute pack, which makes flying as safe as walking on the ground. A wire goes over

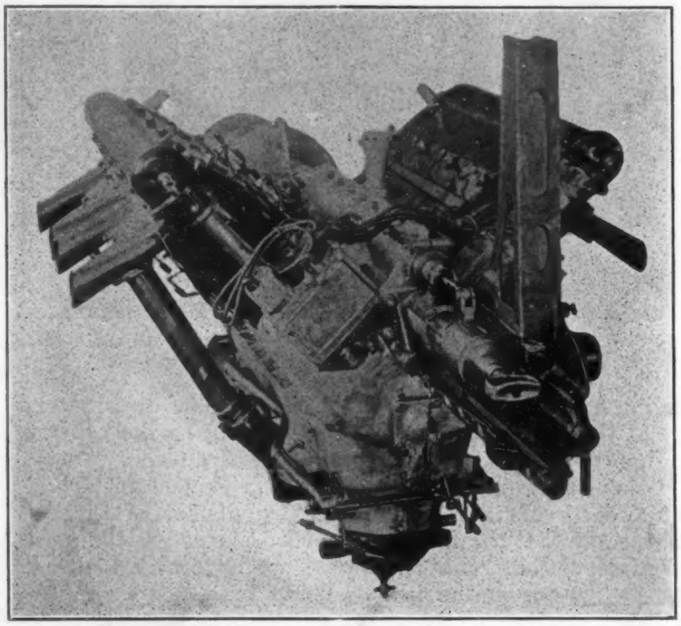


SINGLE CYLINDER ENGINE BASE USED FOR RESEARCH TESTS

the man's shoulder and has a ring in front which he pulls when ready to open the parachute after getting clear of the airplane. We have had over 100 jumps at McCook Field during the year. Recently several men jumped in one day down on the Mexican Border. Another development for this purpose is the seat pack, which takes the place of the pack on the back and serves as a cushion seat.

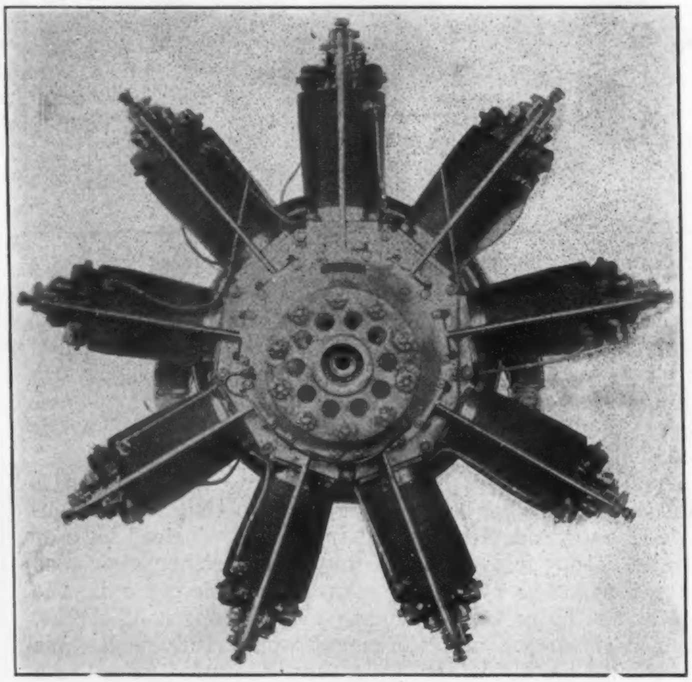
A new development is a Browning machine-gun, the latest 30-caliber and 50-caliber air gun. They can be used on pursuit airplanes. The ammunition includes the 30-caliber, the 50-caliber, and the 11-mm. The 11-mm. ammunition is incendiary. Airplane tanks have been set on fire by one shot from one of those 11-mm. shells.

A synchronizing outfit includes a machine-gun and a Nelson synchronizer. The latter is turned slowly and one shot is fired; then it is turned through 180 deg. and another shot is fired. It is revolved at 500 r.p.m. and makes a group on one side only, the disc is turned at

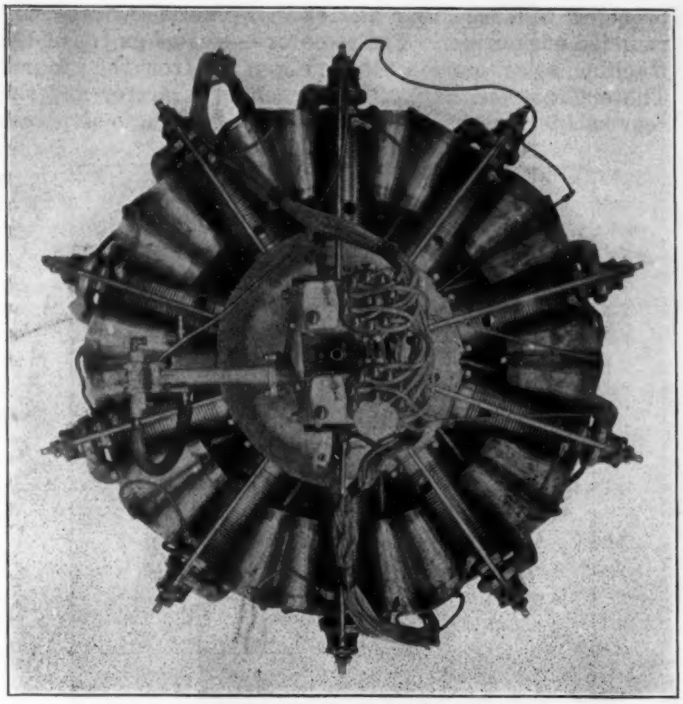


HISPANO-SUIZA ENGINE EQUIPPED WITH A 37-MM. CANNON FIRING THROUGH THE PROPELLER

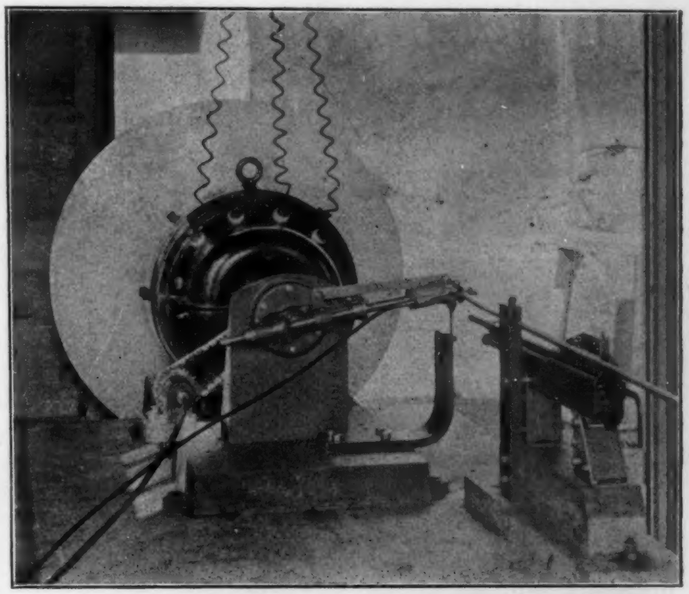
1000 r.p.m. and the group is there. This shows how far the bullets miss the propeller, and the enormous range of speed that the synchronizer must stand from zero to 2000 r.p.m. Still it only uses about 90 deg. of the arc and it has 180 deg. that it could use. The distribution



FRONT VIEW OF THE A.B.C. NINE-CYLINDER RADIAL AIRCRAFT ENGINE



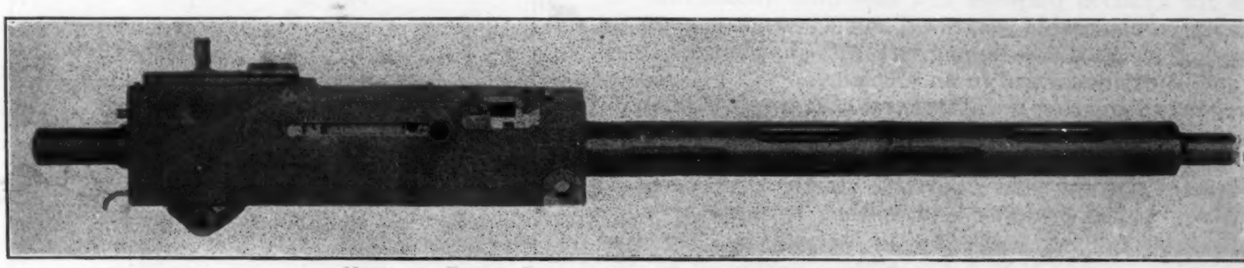
FRONT VIEW OF THE SMITH RADIAL AIR-COOLED AIRCRAFT ENGINE



APPARATUS FOR TESTING GUN SYNCHRONIZATION

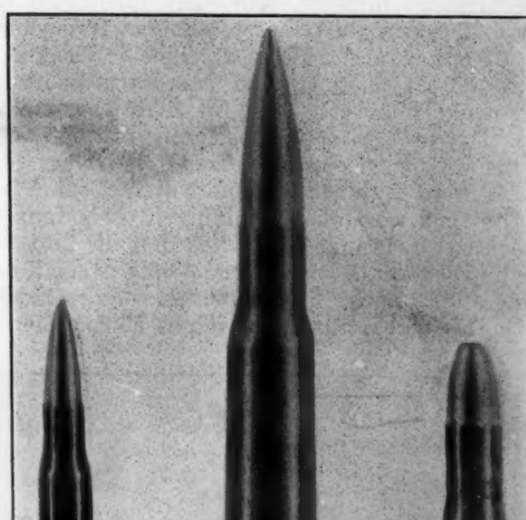
increases with the number of revolutions. We practically never have a shot that goes near the propeller.

At McCook Field we have a baggage car for the pur-



VIEW OF RIGHT SIDE OF THE BROWNING MACHINE GUN

BACK AND SEAT PARACHUTE PACKS



THE 30-CALIBRE, 11-MM. INCENDIARY AND 50-CALIBRE CARTRIDGES USED IN AIRPLANE ARMAMENT

Photographic Truck Developed for Field Use

pose of installing photographic equipment and making drawings. In case of war we could equip baggage cars very quickly and supply them to the troops at the front. We have a camera weighing about 100 lb. and using plates. Originally we had difficulty in using films because the film could not be held steady. We are now able to use a type M-1 camera, which is the standard all-round camera for aviation purposes and uses films successfully thus saving considerable weight. The old French camera that we had weighed 140 lb. and has been abandoned. It could not be easily carried in an airplane.

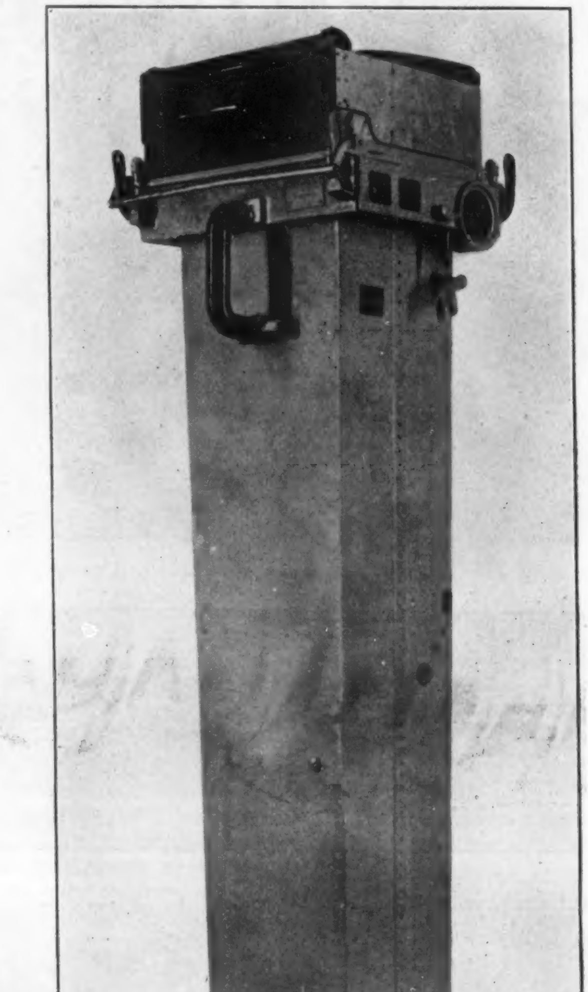
In regard to starting apparatus, without a self-starter on an airplane to whirl the propeller it must be done by hand. On many planes it may not be desirable to have a self-starter; so, we have a portable starter that comes up and whirls the propeller and is then released by a clutch.

Armored Airplanes

The armored airplane previously mentioned has two Liberty 12-cylinder engines, eight Lewis machine-guns and a 37-mm. cannon. This airplane is designed to fly low, at 100-ft. altitude, and concentrates its fire on the ground. I honestly believe that a group of airplanes such as this could absolutely prevent an enemy from mobilizing on our borders. It is a very ferocious thing. It was designed and built at McCook Field and, from the time we started building it, only four months was required to complete it and put it into the air.

During the war Captain Lepere built a small armored airplane at the Packard plant which we also have in the air. In this airplane, which weighs about 8600 lb., the propeller is at the rear and each engine is entirely surrounded with armor. The radiator is located on top of the machine, so as to protect it from gun fire from the ground. The entire front half of this machine is armor and the rear half is veneer. We are building 10 of these airplanes for use on the Mexican Border. Gasoline is carried inside the armored nacelle.

For the fiscal year ended June 30, 1920, we had $4,000,000 to spend for experimental purposes at McCook



The Gaumont 120-Cm. Camera
Complete Weight, lb. 61
Weight of Camera Body, lb. 39
Weight of Magazine Loaded, lb. 22
Height of Camera with Magazine, ft. 5
Plan Dimensions, in. 10½ x 13

Airplane Engine Starting Device Developed at McCook Field

Field. Next year we will have $5,000,000, so this development can be continued. We asked for more money but with that much we can make some developments.

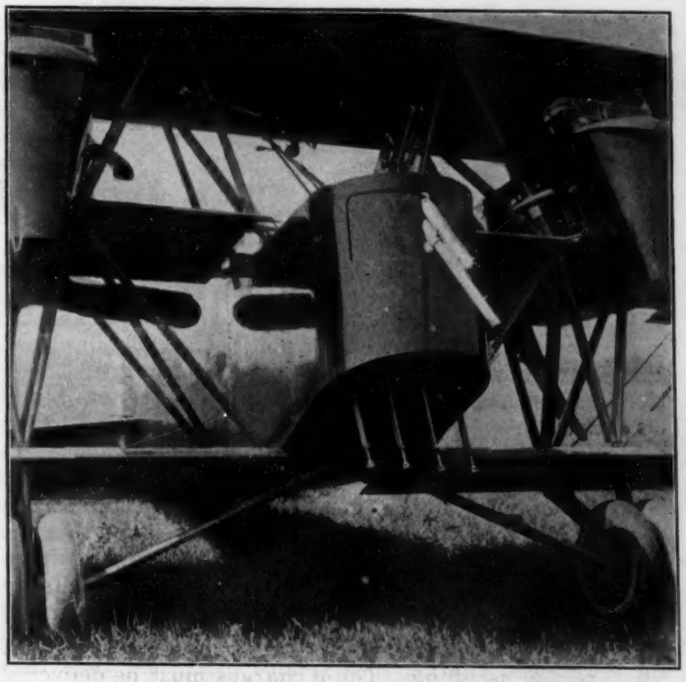
At the greater altitude it becomes desirable to have a propeller in which the pitch can be changed. In landing, the pitch can be reversed and the engine run wide open, thus providing a brake to force the airplane backward. A propeller which works that way is operated by a lever on the right-hand side of the cock-pit. In a demonstration of how this will shorten up the landing of an airplane, we measured many landings without using the reversible pitch propeller; the airplane ran 275 ft. along the ground before stopping. By changing the pitch the landing distance was cut down to 75 ft. An airplane can land in a very small field when it is equipped with a device of this nature.

RELATION OF MILITARY AND COMMERCIAL AVIATION

In the military service, we feel that the commercial aviation can be developed side-by-side with military aviation. Anything that we develop for military purposes, for instance this variable-pitch propeller, is certainly valuable in commercial aviation. The same is true of large air transports carrying troops. They immediately become available for use in commercial aviation. The same is true of parachutes and, of course, the improvements in engine and airplane design are immediately available. Many believe there will not be much progress in commercial aviation for a number of years, but commercial aviation is bound to come.

The transport machine has made several non-stop flights to Washington from Dayton. The pilots are entirely enclosed. There are two windows in front that can be opened and they are habitually open, but the air flies by so fast that it does not enter the windows, although it provides some ventilation. This airplane weighs 10,000 lb. when completely loaded. On one of these airplanes we are now mounting a 3-in. cannon, which fires a 15-lb. projectile. We have fired this cannon on the ground; after the machine is assembled ready for the air, the cannon will be fired from the air. This transport is equipped with electric motor starters.

The airplane hospital ambulance may be useful from a commercial standpoint. A patient can be taken to a hospital quickly from an outlying district. The designer is Mr. Verville. This is an ordinary DH-4 machine remodeled to take two patients in stretchers. There are four such airplane ambulances in operation on the Mexican Border. We have in the Air Service more than 40 medical officers who are also pilots. The injured are given first-aid treatment, put in the airplane and rushed to the base. When they arrive, the ambulance is waiting and the injured men are taken to the hospital. It is not an impossible proposition or a dream to imagine that rapid transportation like that would be useful for emergency patients. If a man were taken with appendicitis down at Mission, Tex., he could be flown up to San Antonio in an hour and a half and operated on there; otherwise he would have to be operated on down there in the dirt and dust and would have small chance for his life. These airplanes will actually be used for that purpose.



ARMORED MACHINE DEVELOPED AT MCCOOK FIELD FOR GROUND ATTACK MOUNTING EIGHT LEWIS MACHINE GUNS AND A 37-MM. CANNON

In parachute jumping, we require each man to wear two packs, one on the chest and one on the back, so that if one parachute should break he could pull the string and use the other. The man, when getting ready to jump, stands out on a platform on the strut. Down on the Mexican Border recently, a man jumped from a 20,000-ft. altitude and it took him 17 min. to reach the ground. One method of leaving an airplane is called "lifting off." There is no jerk; the motion is very easy. It is like jumping from a 10-ft. embankment to land in a parachute. The men suffer no injury whatever. One man fell 300 ft. before he pulled the string. When asked why he delayed so long before pulling the string he said, "Well, I was afraid I would break it." Recently two men walked out to the end strut of an airplane, while in the air, and lifted off together. The rate of speed of the fall is from 16 to 24 ft. per sec.

A moving picture taken during General Mitchell's recent inspection of McCook Field shows a spotlight bullet as we call it, fired from an 11-mm. machine-gun. One shot into a tank destroys the fuselage of an airplane; it sets the leak-proof tank on fire. This bullet carries some fulminate and some magnesium ribbon inside which ignites as soon as the gun is fired, hits the gasoline on the edge of the tank and sets it on fire. Even our leak-proof tanks which will allow 50 bullets to be fired into them will not withstand this spotlight bullet.

The Utilization of Present Automotive Fuel[1]

By Frank C. Mock[2]

THE economic usefulness of the automobile and the motor truck lies in their ability to reach all places, travel at all speeds and overcome all road conditions. This has led to the development of a powerplant operating through a great range of speed and load. Conservation of the life of the mechanism and considerations of weight and vibration require that this powerplant be made up of multiples of relatively small working cylinders. These two considerations together require that the individual fuel charges be small and be fed in infinitesimally small periods of time. In the case of the ordinary passenger car engine the individual fuel charges vary in volume from that of a sphere of about 3/16-in. diameter for a full-load charge, to a volume much less than that with the engine idling. These charges must be delivered in 1/6 sec. at the lowest engine speed, or in 1/100 sec. at very high speed. In 32 years of intensive study and research but one method has been found of accomplishing this fuel feed with an accuracy which will give any sort of satisfactory operation. This method involves metering the fuel along with and under the same force as the air flow and delivering it to the cylinder either as a vapor or fine mist commingled with the air charge. Whatever drawbacks exist in the fuel system of our automotive engines today are not attributable to this principle, but to failure to function according to it.

Impossibility of Fuel Atomization

There are still some who believe that the failure to evaporate present gasoline in the intake systems of our engines is due to improper metering or insufficient atomization in the carbureter. The best inswer to this is that experiments show that this gasoline cannot possibly atomize at the temperatures and under the conditions of operation in many of our motor cars. If a measured quantity of this gasoline is placed in a receptacle with sufficient air at atmospheric pressure for complete combustion, at 100 deg. fahr. only about one-third of the fuel will be evaporated, and a temperature of 160 to 180 deg. fahr. will be required before the whole can possibly change into the vapor state. At the present time probably 90 per cent of the motor cars in use are operating with an intake manifold temperature below 120 deg. fahr. Under such conditions the fuel feeds to the cylinders irregularly and intermittently. To insure satisfactory operation under the requirements of changing load and speed it is usually necessary to increase the richness of mixture from 15 to 30 per cent and this practice is highly detrimental to many functions of the mechanism as well as a notable economic waste of fuel. It is somewhat difficult to maintain a vaporizing temperature of 160 to 180 deg. and this high temperature is objectionable for a number of reasons. The most frequent objection is that it will reduce the power of the engine, necessitating a 5 per cent larger and heavier powerplant. It becomes more difficult to cool the engine and to obtain adequate lubrication under heavy loads in hot weather. These high temperatures greatly increase the tendency of the fuel to detonate or knock, compelling the adoption of lower compression pressures with a resultant loss in fuel economy.

Vaporization is more readily accomplished under partial vacuum and this fact alone makes it possible to keep many of our motor cars and trucks in use today. As the throttle is closed, in the present system of engine control, the air charge to the engine is rarified, being reduced from atmospheric pressure at full load to about 6 lb. absolute at no load. This latter pressure is part air and part exhaust residue. The effect of this pressure drop upon the vaporization temperature may be illustrated by the typical case of decane which is a paraffine series gasoline component of about 360-deg. fahr. boiling point. The vapor of this element reaches a density of one-fifteenth that of atmospheric air at a barometric pressure of about 29.5 in. and at 109 deg. fahr. It would reach one-fifteenth the density of air at about 5 lb. absolute pressure, the idling charge condition of an engine, at between 70 and 80 deg. fahr. Thus, under ordinary conditions, the vaporization is much more complete at closed throttle. The limits of the application of vacuum are obvious; partial vacuum in the intake passage means rarification of the air charge and reduction of the engine power and application of the vacuum principle externally would require an extra expenditure of fuel for that purpose.

Mechanical Atomization at Low Temperatures

Experiments show that mechanical atomization without increase of temperature is effective when the fuel is sprayed directly into the cylinder or the intake valve port but is not effective under the ordinary system of supplying a number of cylinders from one common manifold. The fuel separates out of the air at the bends and turns of the manifold and adheres to its walls thereafter causing the same troubles of erratic feed to the cylinders experienced with ordinary systems under similarly low temperatures.

If the spray from the carbureter is directed upon a surface or hot-spot heated to a temperature near or above the end-point of the fuel, the already fine drops from the carbureter will be broken up into even smaller particles. It is possible to produce this condition with good engine operation at a mixture temperature of from 40 to 50 deg. fahr. below the temperature of complete vaporization of the fuel. This device seems to have the valuable characteristic of a natural and inherent temperature regulation and works out to a very simple structure without mechanical complication.

With fuel of the present end-point, the exhaust temperature is adequate even with the engine idling, but if the end-point should be raised, a condition will be reached

[1]From a paper presented at the meeting of the American Petroleum Institute, Washington, Nov. 17-19, 1920.

[2]M.S.A.E.—Research engineer, Stromberg Motor Devices Co., Chicago.

where the exhaust temperature at light loads will be too low for proper action and an external application of heat will become necessary.

About 30 per cent of the passenger cars and 5 per cent of the trucks operating today have partially effective means of heating the intake charge and give fair operation during eight or nine months of the year. Most of the larger passenger cars built in the last 18 months are provided with intake systems that give fairly good operation all the year round. Not all of their devices produce proper temperature regulation the year round, but sufficient advancement has been made to indicate that within a year or so we will have the problem whipped if the fuel stays as it now is. In motor boats much less advance has taken place in manifold heating. The tractor industry has for some time been trying to burn kerosene as fuel. While it is not safe to say that this has been fully worked out, nevertheless they have learned how to use gasoline efficiently.

The first and most important future fuel requirement of the automotive industry is stability of fuel characteristics. The automotive industry is so massive that it requires several years for a simple change like the heated intake manifold to become generally adopted. When we consider that many motor cars are used from five to seven years it can be readily seen that it would take nearly a decade for any general changes in engine construction to take place. The troubles encountered with casinghead gasoline in warm weather, and blends of high test gasoline and kerosene in cold weather, are minor instances of difficulty resulting from the variation in fuel quality.

The invention and general use of an ingredient which can be added to the present fuel to prevent detonation is of almost equal importance. This will permit more satisfactory operation with present compression and a development in the direction of higher compression pressures with a resultant gain in the fuel economy that can be obtained.

OIL PIPE LINES.[1]

THE oil pipe line is as fundamentally a part of the oil industry as the railroad is of most other American industries. First introduced about 56 years ago, it has so demonstrated its superiority as a means of carrying crude oil from the well to the refinery that it has largely superseded all others. This has made possible the building of refineries in or near the large consuming centers, rather than at the wells, which are usually remote from the centers of population.

The pipes for conveying the oil are laid on the surface of the ground, or at a depth varying from 18 in. to 3 ft. beneath the surface, and the main lines are generally 8 in. in diameter. The oil is forced through the pipes by means of pumps operated either by steam or by internal-combustion engines. The pump stations are located from 1½ to 90 miles apart, varying with the condition of the country through which the pipe lines extend, and the viscosity of the oil to be handled. Some of the larger pipe-line systems are hundreds of miles in length. It is estimated by the United States Geological Survey that the mileage of oil trunk lines in the United States today approximates 34,000, and that the gathering systems, which are a fundamental part of the trunk systems, aggregate about 11,500 miles in length, making a total of 45,500 miles. At the time most of the lines were constructed, the average cost per mile based on 8-in. pipe was about $6,500. The cost of the average pump station at that time varied from $130,000 to $250,000. The cost at present, on account of the increase in price of labor and materials, would be much in excess of these figures. The fixed investment in pipe lines corresponds closely with the actual cost of the property, and is estimated to be approximately $500,000,000.

The difference between the published pipe-line tariff rates and the railroad rates for shipping crude oil has always been so large that refiners and producers, even though they have no pipe-line systems of their own, cannot afford to ship by rail, except for comparatively short distances. The pipe-line rates, although greatly increased in recent years, are still much lower than those charged by the railroads for tank-car shipments.

The pipe specifications require that it be of a uniform quality of steel, that the threads be carefully made so as to make as perfect a union between joints as possible, and that it be capable of safely withstanding an internal pressure of 2000 lb. per sq. in. In some instances the pipes have been joined by pipe machines. Cases are on record where one pipe machine, operated by a gang of 28 men, has laid as much as 8700 ft. of 8-in. pipe in one day of 9 hr., whereas the usual accomplishment of an ordinary gang of 40 men is from 2500 to 4000 ft. per day.

The viscosity of the oil to be transported, and the topography of the country through which the pipe lines pass, are the factors determining the distance between pumping stations. The average distance in the Mid-Western and Eastern States is about 35 miles, while the average in California, where a relatively thick, viscous oil is handled, is about 12 miles, although stations are sometimes not more than a mile and a half apart, and in extreme cases are placed as much as 90 miles apart. The pumps are designed to deliver through an 8-in. pipe line approximately 30,000 bbl. of oil in 24 hr., working under a line pressure of 700 to 900 lb. per sq. in.

Practically all the pipe-line companies engaged in the transportation of petroleum have, in addition to their trunk lines, extensive systems of gathering lines. These are provided for the purpose of collecting the oil from the producers' tanks and running it to a tank farm or to some point where it can conveniently enter the main trunk lines. In some cases, however, these gathering systems are owned by the producing companies. As in the case of railroad operations, it is necessary to provide means for instant communication between different parts of a pipe-line system. For this reason it is usual for the pipe-line companies to own and operate their own telegraph and telephone systems.

[1]From an address delivered by C. P. Bowie at the convention of the Independent Oil Men's Association, Denver, Col., Sept. 30, 1920. Mr. Bowie is petroleum engineer, Bureau of Mines, Washington.

The Present Status of the Isolated Gas-Electric Generating Plant

By CHARLES FROESCH[1]

METROPOLITAN SECTION PAPER *Illustrated with* PHOTOGRAPHS AND DRAWING

ELECTRICITY is unquestionably the most satisfactory medium used today for power and light, not only because it is safe, convenient and most flexible, but because it is beautifying and attractive. The low cost of fire insurance made possible by the use of

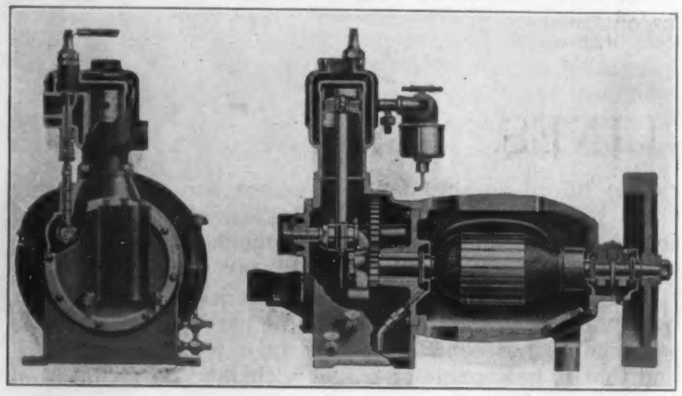


FIG. 1—END AND SIDE SECTIONAL VIEWS OF A 32-VOLT 300-WATT FULL AUTOMATIC PLANT

electricity on the farm almost warrants its installation, this being 50 or 60 per cent of the cost of insurance when other lighting methods are employed. Electric light and power for the farm are meeting with constantly increasing popularity and, as only a comparatively small number of farms are electrified at present, the lighting-plant market is growing with surprising rapidity. To understand the magnitude of this field and its requirements, a brief survey of existing conditions is necessary. The following figures taken from a statistical report issued by the Department of Agriculture, while approximate at best, cannot be ignored.

There are today 6,400,000 farms in the United States having an average area of 140 acres. However, only 40 per cent of these have more than 100 acres of area. It would not be fair to judge the market for isolated plants by these farms only, because many farmers having less than 100 acres can well afford to buy a lighting plant, while many owners of larger farms cannot or would not. We can say conservatively that one-third of the smaller farms and four-fifths of the larger ones form the future market. This gives a total of 3,328,000 farms. However, we must deduct from this total a number of different plants already installed and farms supplied directly by central power stations. Estimating the total number of isolated electric plants made up to the present at 200,000, and the number of farms supplied with central-station current at 7 per cent of the total, approximately 2,580,000 farms are available as a market for the isolated gas-electric lighting plant. Farmers are most conservative and discriminating and speak and act from experience. It is my firm belief that when the usefulness and necessity of the isolated lighting plant shall have been fully proved, every one of these farms will be electrically lighted.

Adequate central-power-station development and service extension in the rural districts cannot be realized in the near future. The influx of people to the cities and the increase in cost of labor and material will keep the utilities companies busy with city problems for several years to come, leaving the field clear of serious competition for the isolated-electric-plant manufacturers. It is true that here and there some steps have been taken to install high-tension electric lines in the country, but in most cases this experiment has been costly to the ultimate consumer, current being generally furnished on a kilowatt-mile basis plus an additional fee for equipment depreciation. The above analysis does not include the possibilities of the use of lighting plants for schools, halls, stores, camps, yachts and the like, or the vast field offered through export.

A lighting plant is expected to give light whenever it is needed and at as low a cost as possible. When the low-voltage plant first appeared several years ago, it was a rather crude affair consisting of a generator, a switchboard and a set of storage batteries, all mounted on a wooden base which in turn was bolted wherever con-

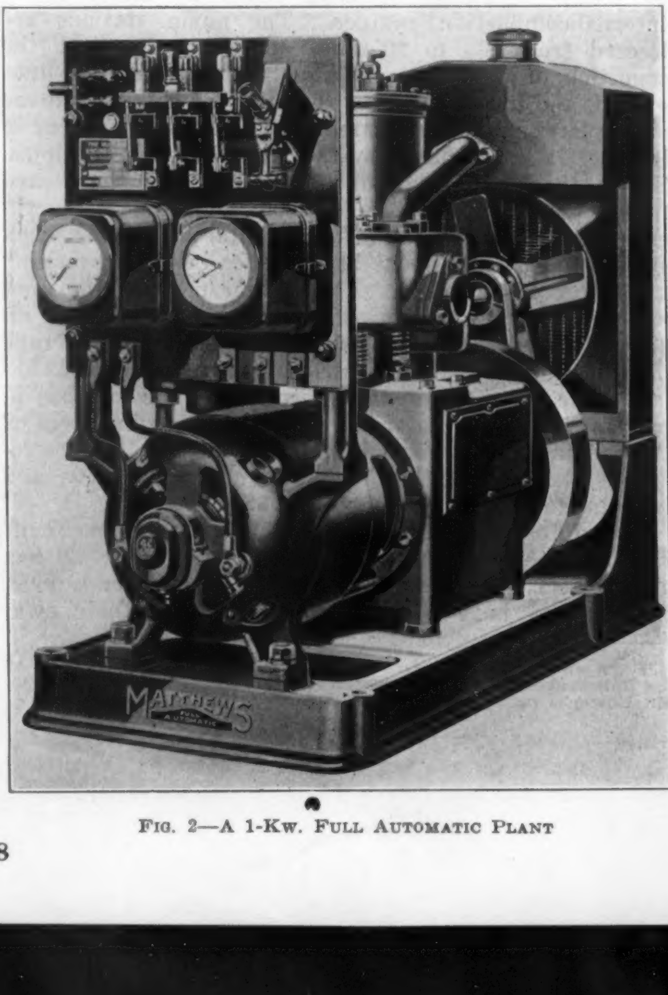


FIG. 2—A 1-KW. FULL AUTOMATIC PLANT

[1]Jun. S. A. E.—Chief engineer, S. W. Merritt Co., New York City.

venient. It was invariably belt-driven by a gas engine bought separately and in most cases too large or too small to handle the generator load efficiently. The voltage regulation, if any, was poor, and the battery entirely too small; but in spite of this the equipment gave fairly good results in the hands of the layman and was decidedly better than kerosene or acetylene lamps. Latterly special engines and generators have been designed and storage batteries greatly improved as to life and reliability. The whole system has been specially adapted to the work to be done.

Common Types of Lighting Plant

Farm lighting plants can be classified in three groups:

(1) Full-automatic plants which, as their name implies, start and stop automatically when the battery is discharged or recharged respectively.
(2) Semi-automatic plants, which must be started by hand but stop automatically when the battery is fully recharged
(3) Assembled plants, which do not contain any automatic features and are in the majority of cases belt-driven

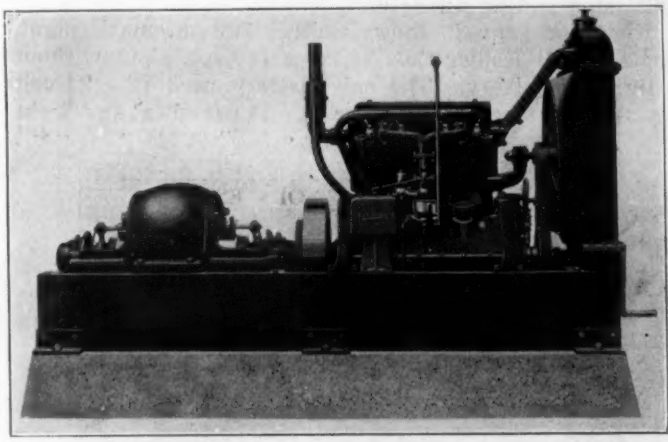


Fig. 3—A 5-Kw. 110-Volt Automatic Plant Which Is Used in Connection with a 108-Amp-Hr. Battery

Each one of these groups is made for 32 or 110-volt service. Some plants have been designed for 60-volt service, but their use is very limited owing to inability to secure motors and electrical appliances that can be run in conjunction with them. I understand that they are used exclusively for motion-picture apparatus.

Each one of the main groups of plants can be subdivided into three classes as follows:

(1) Plants furnishing power from the generator alone
(2) Plants furnishing power from the generator and the battery, or the battery alone
(3) Plants furnishing power from the battery and generator combined, or from the battery or the generator alone. The 32-volt semi-automatic plants furnishing power from the generator and the battery, or from the battery alone, are the best known plants today

The specifications issued by the lighting-plant section of the National Gas Engine Association regarding battery equipment and generator rating is interesting and worth noting. The following cell equipment is recommended for these plants:

(1) For 32-volt service, 16 cells of the lead type; or 25 cells of the Edison type

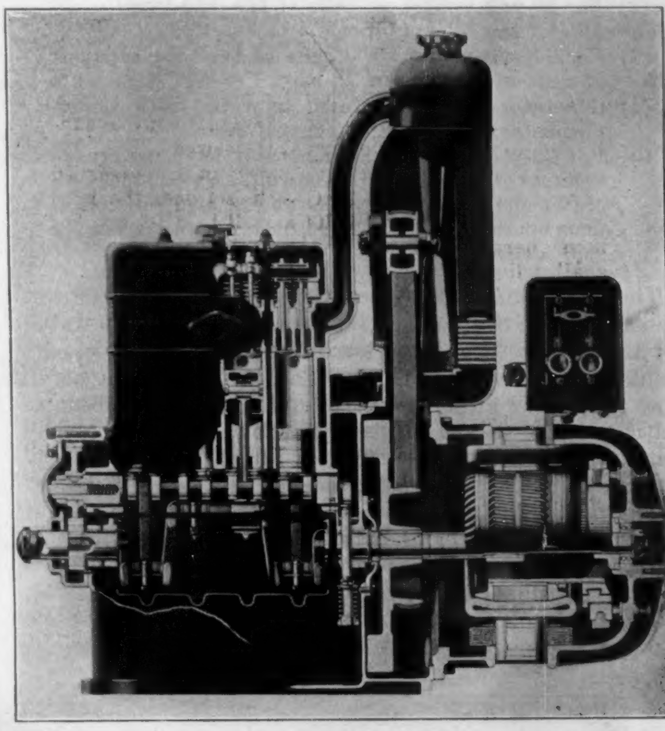


Fig. 4—Sectional View of a 110-Volt Full Automatic Plant Which Has a Full Pressure Oiling System and Does Not Use a Lighting Battery

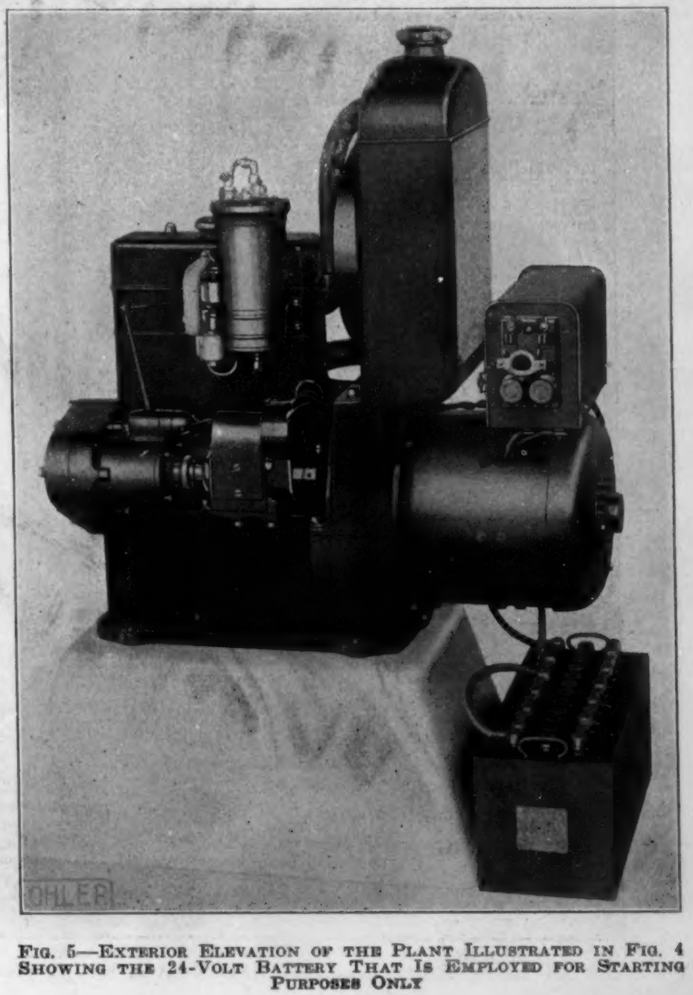


Fig. 5—Exterior Elevation of the Plant Illustrated in Fig. 4 Showing the 24-Volt Battery That Is Employed for Starting Purposes Only

(2) For 60-volt service, 32 cells of the lead type; or 50 cells of the Edison type
(3) For 110-volt service, 56 cells of the lead type; or 92 cells of the Edison type
(4) Generators are to be rated in watts, with a supplementary rating in amperes if desired
(5) For 32-volt service, the generator shall deliver 36 volts at full load. For 60-volt service, the generator shall deliver 72 volts at full load for continuous operation. For 110-volt service, the generator shall deliver 125 volts

The Consolidated Utilities Corporation manufactures a complete line of lighting plants ranging from 300 watts, for the 32-volt type, to 10 kw. for the 110-volt type. Its plants are known to the trade as the Matthews plant. They are made either with full-automatic or semi-automatic control. Fig. 1 on page 28 shows the 32-volt, 300-watt plant. It has a one-cylinder four-cycle gasoline engine of 2-in. bore and 3-in. stroke, developing 1 hp. at 1200 r.p.m. The generator has a maximum capacity of 450 watts. Two sizes of battery are furnished with this plant, a 55 amp-hr. glass-jar type, or a 70 amp-hr. enclosed-type rubber jar. Fig. 2 on page 28 shows the Matthews 1-kw. plant. It has a single-cylinder four-cycle gasoline engine of 3-in. stroke, developing 3½ hp. at 1250 r.p.m. The generator which is of the four-pole design has a capacity of 1000 watts for continuous operation. The battery capacity is 75 amp-hr. for the 32-volt sets, and 36 amp-hr. for the 110-volt sets. The full-automatic switchboard is shown. On the left is an ordinary ampere-hour meter and on the right a similar meter controlling the battery automatically. Immediately above the latter meter is the overload circuit-breaker, which disconnects the circuit as soon as the load increases above a safe limit.

Fig. 3 on page 29 shows one of the largest Matthews plants, made only for 110-volt service and used with a 108-amp-hr. battery. This plant is rated a 5 kw. The engine is a four-cylinder four-cycle overhead-valve type, having 3½-in. bore and 5-in. stroke and developing 20 hp. at 900 r.p.m., its rated speed. The generator is 110-volt for starting and lighting, with a separate booster commutator for charging the battery. It is driven by a fabric disc coupling. The switchboard is arranged for full-automatic control and has a starting rheostat, a separate voltmeter and an ammeter.

Fig. 4 on page 29 shows another full-automatic plant, made by the Kohler Co. It is a 110-volt plant without a lighting battery. The only battery used is a 24-volt set for starting purposes only. Depressing any light

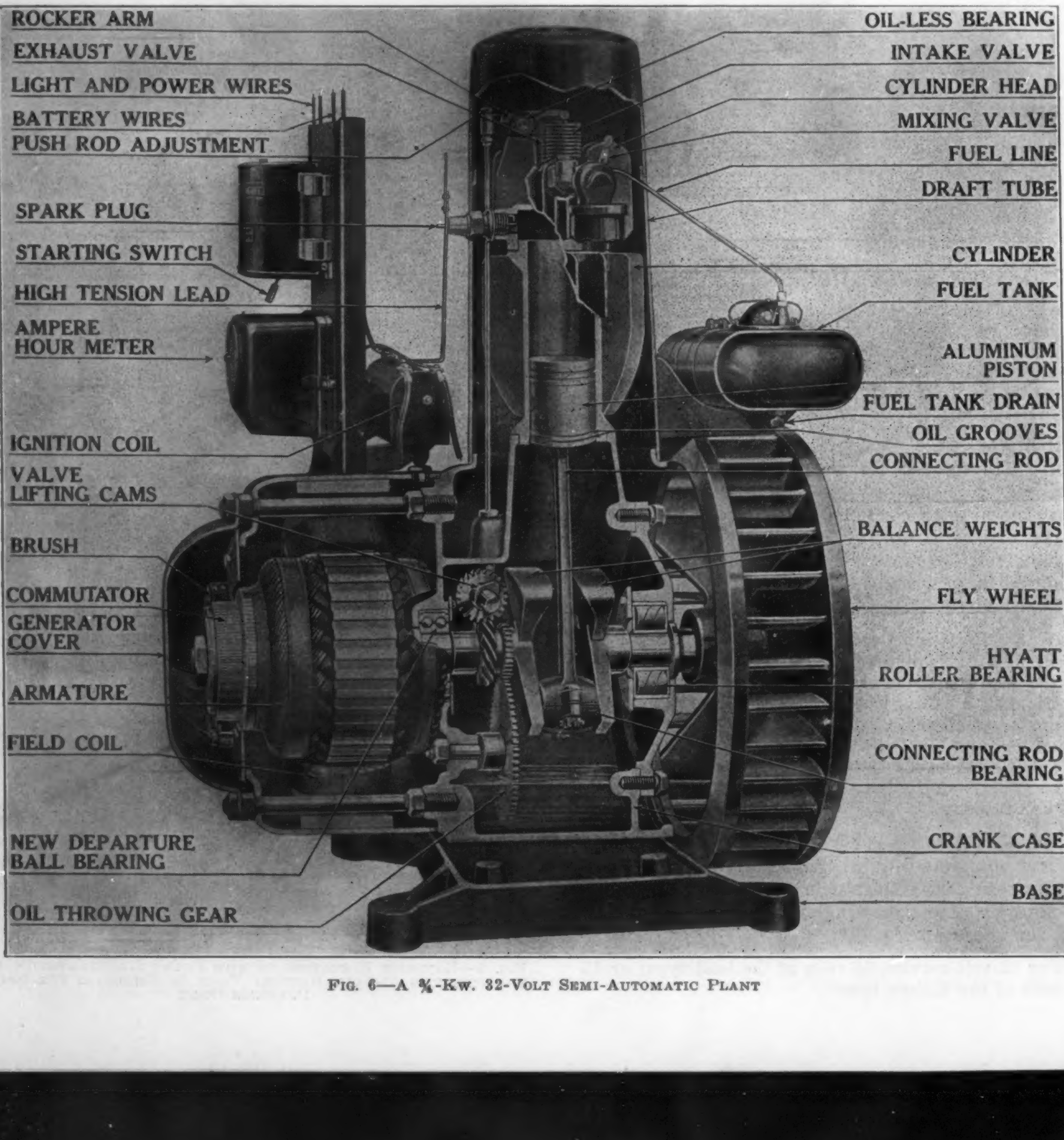


Fig. 6—A ¾-Kw. 32-Volt Semi-Automatic Plant

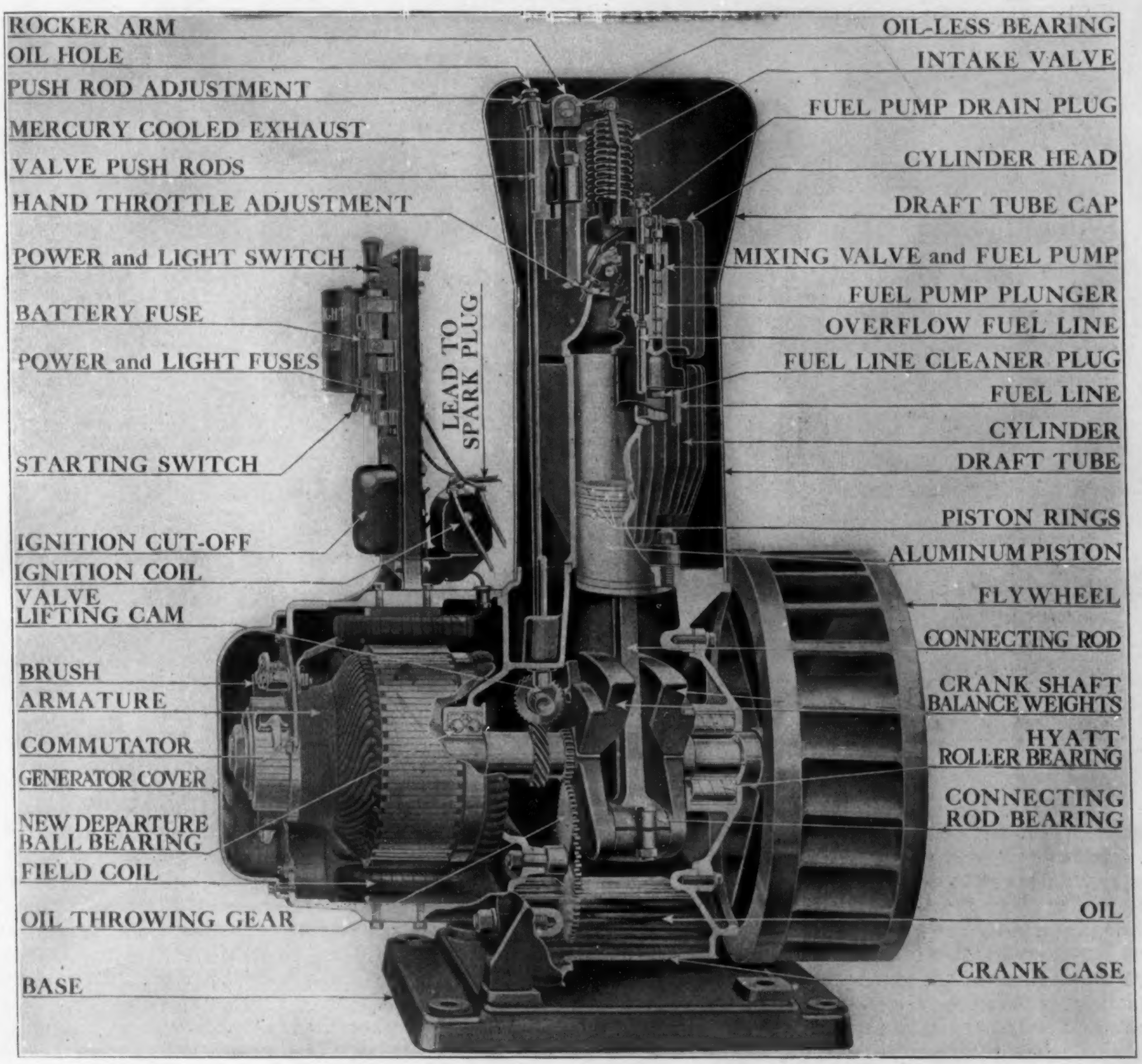


FIG. 7—A 3-KW. SYSTEM WHICH IS BUILT FOR 110-VOLT SERVICE ONLY

switch in the circuit automatically starts the plant; when the light goes out, the plant stops. It has a four-cylinder engine of 2-in. bore and 3-in. stroke, developing 3½ hp. at 1000 r.p.m. The engine follows standard automobile engine practice, having magneto ignition and a float-chamber carbureter with a vacuum feed system. This generator is rated at 1½-kw. and is compound wound. The switchboard provides complete automatic control of the plant; the controls are sealed in a box. Fig. 5 on page 29 shows the complete installation.

Fig. 6 shows the smallest of the Delco plants, which is seemingly one of the most popular. The illustration is self-explanatory and indicates almost every detail. All bearings are of the ball or roller type and the generator armature is overhung. This plant is of the 32-volt semi-automatic type and is used in conjunction with a storage battery of 160-amp-hr. capacity. It is rated at ¾ kw. It is an air-cooled plant, air being drawn through slots in the head cover and the cylinder, and expelled by a fan flywheel of the sirocco type. Lubrication is by splash from the gears. The crankshaft is counterbalanced.

Fig. 7 shows the largest size of Delco plant; it develops 3 kw. and is built for 110-volt service only. Its design and construction are similar to that of the smaller size. The Delco plants are made to run cn either gasoline or kerosene. Fig 8 on page 32 shows a water system designed by the Delco engineers for use in conjunction with lighting units; a small electric motor operating a single-cylinder water-pump through a train of worm gears, in conjunction with a water tank; it is automatic in its operation, starting when the tank is empty and stopping when fully recharged. It works on the pressure principle.

Fig. 9 on page 32 shows the C-Y-C plant built by Carlton, Young & Catlin, Inc. It is a 1½-kw. 32-volt plant, comprising a single-cylinder four-cycle gas engine of 3¾-in. bore and 4-in. stroke, developing 5 hp. at 1200 r.p.m. It is equipped with a pulley for directly driving accessories. The generator is of the two-pole design and compound-wound. The switchboard control is of the semi-automatic type. The piston, rings, pin, connecting-rod, valves and springs of the engine are standard Ford parts. This ought to be an advantage when repair parts are needed.

Fig. 10 on page 33 shows a sectional view of the Lalley plant. It is a 32-volt semi-automatic plant of 1¼-kw.

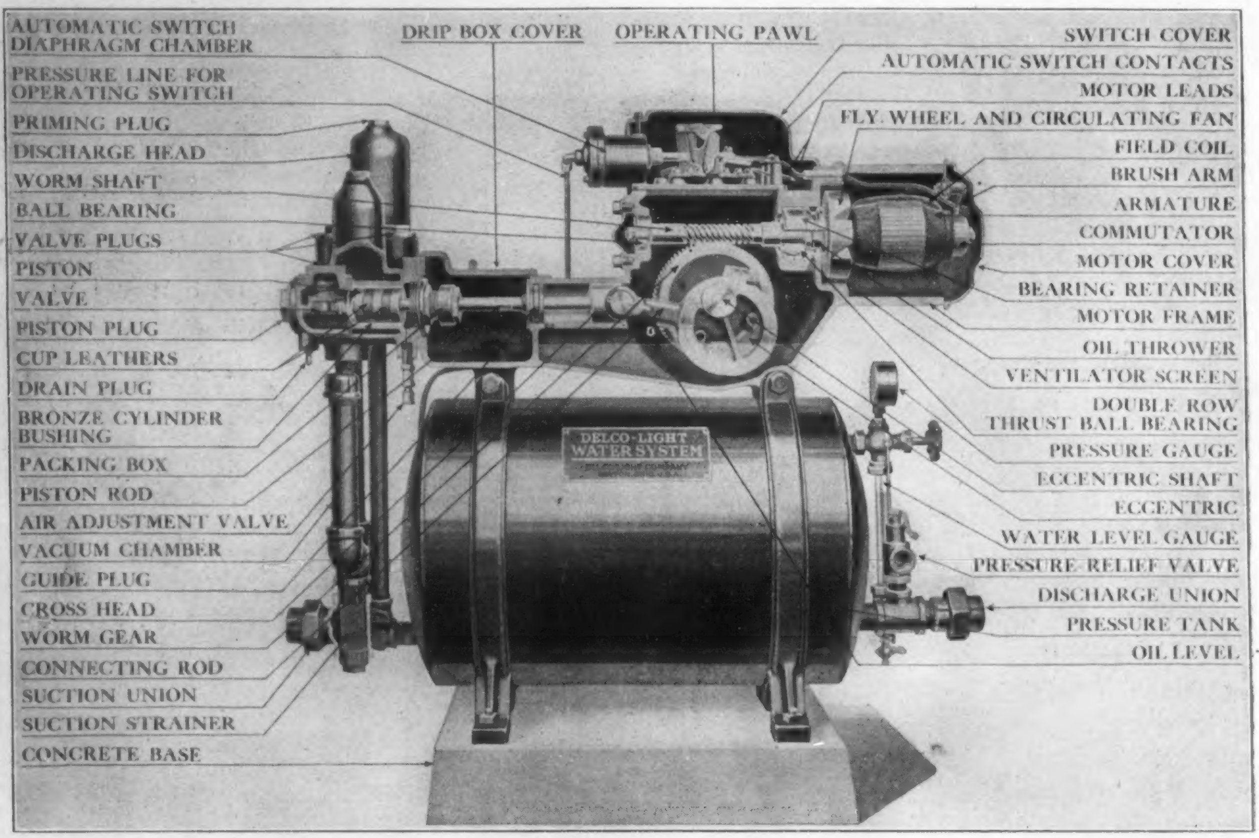


Fig. 8—An Automatic Water System Which Has Been Designed for Use in Conjunction with the Lighting Units Illustrated in Figs. 6 and 7

capacity. The engine is of the single-cylinder water-cooled two-cycle type, having 2⅝-in. bore and 2-in. stroke. It is governed mechanically to run at a speed of 1800 r.p.m. and develops 2½ hp. at that speed. Lubrication is provided by mixing a certain amount of oil with the fuel which is stored in the base. The flywheel is located between the engine and the generator. The generator is of the standard four-pole design and driven by a flexible coupling. The battery has a capacity of 115 amp-hr. Fig. 11 is an outside view of the plant; and Fig. 12 gives a view of the complete installation.

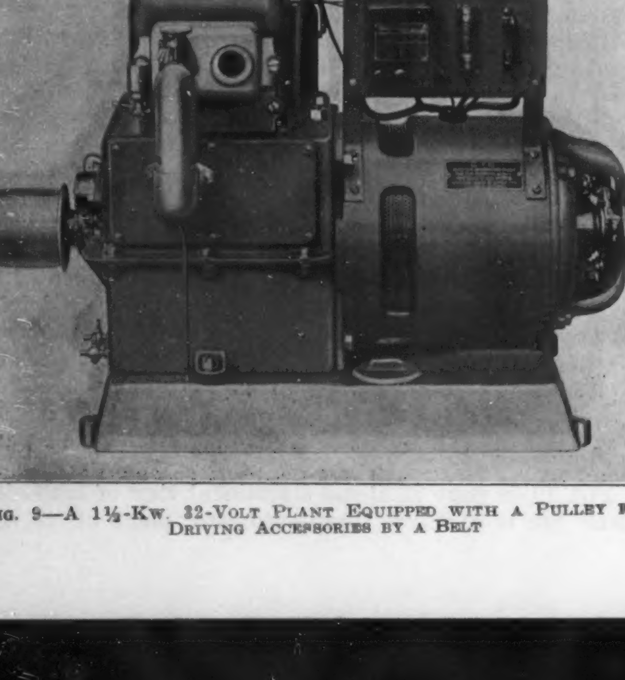


Fig. 9—A 1½-Kw. 32-Volt Plant Equipped with a Pulley for Driving Accessories by a Belt

Figs. 13 and 14 on pages 34 and 35 show the Merritt plant, with which I am particularly well acquainted. The design follows conventional lines but, while there is nothing of startling originality about it, simplicity and compactness have been made keynotes. The capacity of this 32-volt plant is 1½ kw. at 1200 r.p.m., with an 1800-watt overload capacity for extended periods. It is a plant of the semi-automatic type furnishing power from the battery and generator combined, or from either battery or generator alone. It is composed of a single-cylinder engine of 3-in. bore and 4-in. stroke, direct-connected to a four-pole generator upon which is mounted the switchboard. The engine develops 3¼ b.hp. at its rated speed. This power is available at the pulley located at the generator end of the plant and can be used to drive any accessory or implement requiring up to 3 hp.

The cylinder of the engine is of the L-head type with detachable head; the bore is water-cooled and the head is air-cooled to permit a more complete vaporization of the lower-grade fuels with the lowest possible loss of volumetric efficiency. The compression ratio is 4.1 to 1. The valves, one inlet and one exhaust, have a clear diameter of 1⅜ in. and an 11/64-in. lift. The push-rods are steel stampings, 1 in. in diameter. The camshaft is located in a plane perpendicular to the crankshaft and directly above it. It is operated by a pair of helical gears. The crankshaft is of the bell-crank type and bored through to receive the armature shaft, which also clamps the flywheel against the shaft. The flywheel has 12 blades which form the cooling fan; these are cast integrally on the side facing the radiator. The design of these blades follows airplane-propeller practice. They draw the air through the generator and the radiator, which is located between the generator and the flywheel, and expel it radially through openings provided around

the flywheel housing. Cooling is by thermosyphon circulation, a cellular radiator is used and a small water-tank is located at the highest point of the return system to regulate the flow of water. The capacity of the cooling system is somewhat less than 2 gal.

Lubrication is furnished by a gear pump located in the bottom of the crankcase, which forms an oil tank of 1-gal. capacity. Oil is supplied under a pressure of 6 to 8 lb. per sq. in. to the crankshaft main bearings and through a hole drilled in the crankweb to the connecting-rod bearing. The upper connecting-rod bearing and cylinder wall are lubricated by the oil escaping from the main and lower connecting-rod bearings. The generator outboard bearing is lubricated by a self-contained ring-oiler following electric-motor practice.

Ignition is furnished by a tap from five cells of the battery and is of the jump-spark type. A roller timer is used in conjunction with a standard Ford ignition coil having its terminals located on the opposite end of the vibrator. The spark timing is fixed.

A 3/4-in. nominal-size carbureter is used. This is merely a mixing-valve with automatic vacuum control for all loads. Fuel is sucked from the engine base, which at the same time forms the fuel tank and has a capacity of 3 1/2 gal. This permits the operation of the plant for about 13 to 14 hr. at the charging rate. Gasoline or kerosene is used. With the latter a small gasoline starting tank is provided. The engine speed is governed by a centrifugal governor that is very sensitive to speed variation.

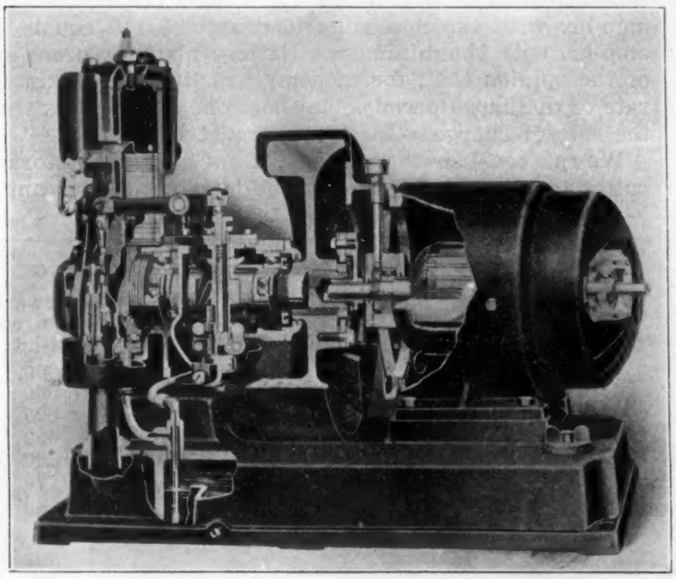


Fig. 10—Elevation, Partly in Section, of a Semi-Automatic Plant in Which the Flywheel Is Placed between the Engine and the Generator and the Fuel Is Stored in the Base

The generator is of the four-pole design with four brushes. The field coils each have three independent windings which are, however, formed and taped together. The first is the shunt winding, the second is a small series winding used to maintain a constant voltage and the third is another series winding used only when the generator becomes a motor to crank the engine. The armature is of the standard drum-wound type and follows conventional practice.

On the switchboard are mounted the cutout or reverse current relay with its "start" and "stop" buttons; the ampere-hour meter, incorporating an automatic ignition switch which opens when the battery is fully recharged and thus stops the engine; a charging indicator; and the line switch with a 30-amp. fuse. The battery used has a capacity of 120-amp-hr. S.A.E. rating.

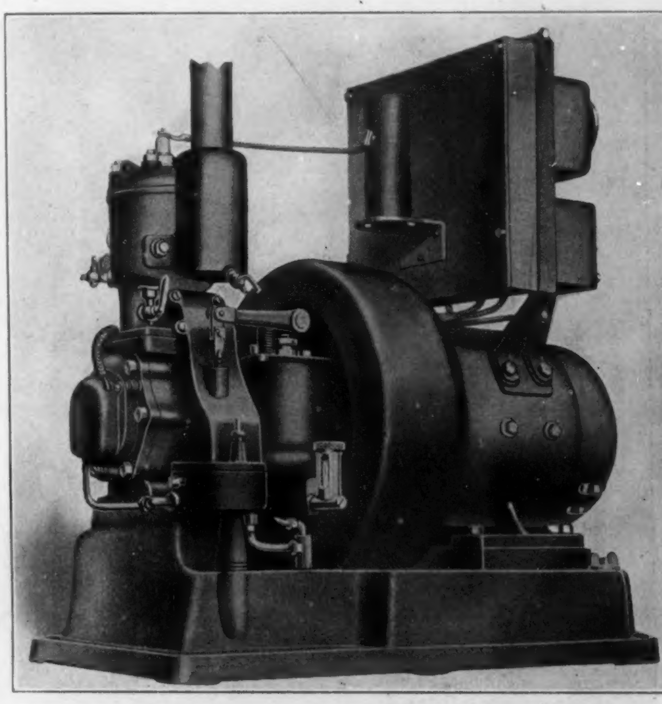


Fig. 11—An Exterior View of the 1 1/4-Kw. Plant Shown in Fig. 10

Characteristics of the Ideal Farm Lighting Plant

It is most difficult to define the characteristics of an ideal plant of the type under discussion. For the sake of argument, let us assume a farm of 100 to 140 acres, analyze and tabulate its requirements as to both light and power and then devise the equipment. We can take the 25-watt lamp as the best for all-around use, as that seems to be the most popular size. The average lighting load per day on the farm is approximately as given in Table 1 on page 34.

The maximum lighting load per hour would occur when all lamps are used simultaneously; but, as this

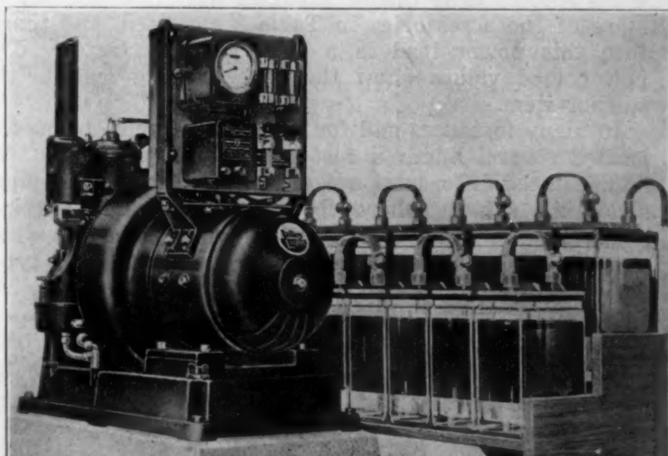


Fig. 12—Another Exterior View of the 32-Volt Semi-Automatic Plant Illustrated in Figs. 10 and 11 Showing the Storage Battery in Place

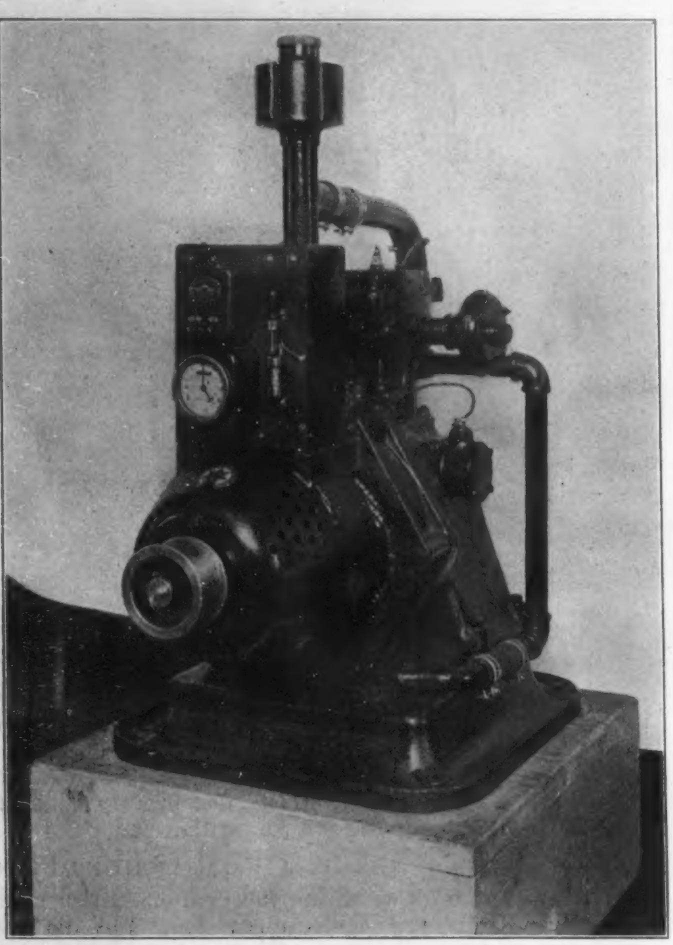


FIG. 13—A 1¼-KW. SEMI-AUTOMATIC PLANT CAPABLE OF FURNISHING CURRENT AT 32 VOLTS FROM THE BATTERY AND GENERATOR COMBINED OR INDEPENDENTLY FROM EITHER ONE

would seldom be the case, we can assume the average lighting load to be sixteen 25-watt lamps, or 400 watt-hr. For a modern farm of this size we can assume that the following appliances and motors are used. The power required is stated in Table 2.

No specific time can be assumed during which one or more of the accessories in Table 2 are used, and therefore this power load is a very variable factor. The power load values show that the lighting load is the smaller item.

In many instances and for different reasons, barns are located several hundred feet from the farm house. To handle these different loads efficiently the lighting plant should be set up where the mechanical and electrical loads are at a maximum, to keep transmission losses at a minimum. The plant must be of the 110-volt type, so that the drop of voltage between the plant and the most distant lamp or accessory will not be sufficient to decrease brilliancy or operative efficiency. Incidentally, this type will permit the use of smaller size wire and standard lamps and appliances. When it is realized that to carry 400 watts a distance of 150 ft. without abnormal voltage loss, No. 6 solid copper wire is required for the 32-volt system, the saving accomplished with the 110-volt installation deserves consideration. With the low-pressure system a drop of 4 volts decreases the lamp brilliancy 25 to 30 per cent.

The capacity of the plant should be sufficient to operate all of the accessories that might be used at the same time; also compromising with the charging load to secure the utmost economy. In Table 2 we would have a maximum power load of approximately 4 hp., representing two-thirds of the farm accessories plus the household appliances such as the electric iron, washing machine and vacuum cleaner. This would mean a 110-volt 22-amp. generator, or 2400-watt capacity at full load. With a charging rate of 4 amp. per hr., the charging load would be two-elevenths of full load.

It must be a battery plant because the lighting load is too small at times to be economically taken care of by the generator. In this instance the current consumption amounts to 400 watt-hr.; or, 400/110 equals 3.63 amp-hr. with the maximum load and 25/110 equals ¼ amp-hr. with the minimum. Battery manufacturers are of the opinion that, for economy and life, the maximum rate of discharge permissible should be slightly less than the rate of charge. This requirement is fulfilled.

We can consider the average life of a lighting storage battery to be 400 cycles. By the term cycle is meant a complete charge and discharge. Taking a battery of 40-amp-hr. capacity we actually have 30 amp-hr. available before a new cycle needs to be started, the remaining 10 amp-hr. being ample to crank the engine. This means that each cycle will last 30/3.63 or slightly more than eight days. The life of the battery under these conditions will be about eight and one-half years. In practice this would be a guess at best, for the reason that the lighting load is not uniform but changes with the seasons of the year. Another reason for a battery plant is that a battery is needed to crank the engine. Whether

TABLE 1—AVERAGE DAILY LIGHTING LOAD

Location	Number of 25-Watt Lamps	Service Hours per Day	Watt-Hours
Kitchen	1	3.0	75
Dining Room	2	2.0	100
Living Room	3	3.0	225
Three Bedrooms	3	0.5	40
Bathroom	1	1.0	25
Porch	1	1.0	25
Basement	1	0.5	15
Barns	5	2.0	250
Miscellaneous	5	1.0	125
Total	22	...	880

TABLE 2—POWER LOAD OF APPLIANCES AND MOTORS

Household	Power Required, Watt-hours
6-Lb. Iron	600
Toaster	500
Grill	500
Percolator	400
Washing Machine	300
Vacuum Cleaner	175
Sewing Machine	50
Farm in General	Power Required, hp.
Milking Machine	¼ to 1
Cream Separator	¼ to 1
Churn	¼ to 1
Refrigerator	¼ to 1
Water-pump	¼ to 1
Corn Sheller	¼ to 1
Bone Cutter	¼ to 1
Small Drilling Machine	¼ to 1
Forge Blower	¼ to 1
Grindstone	¼ to 1

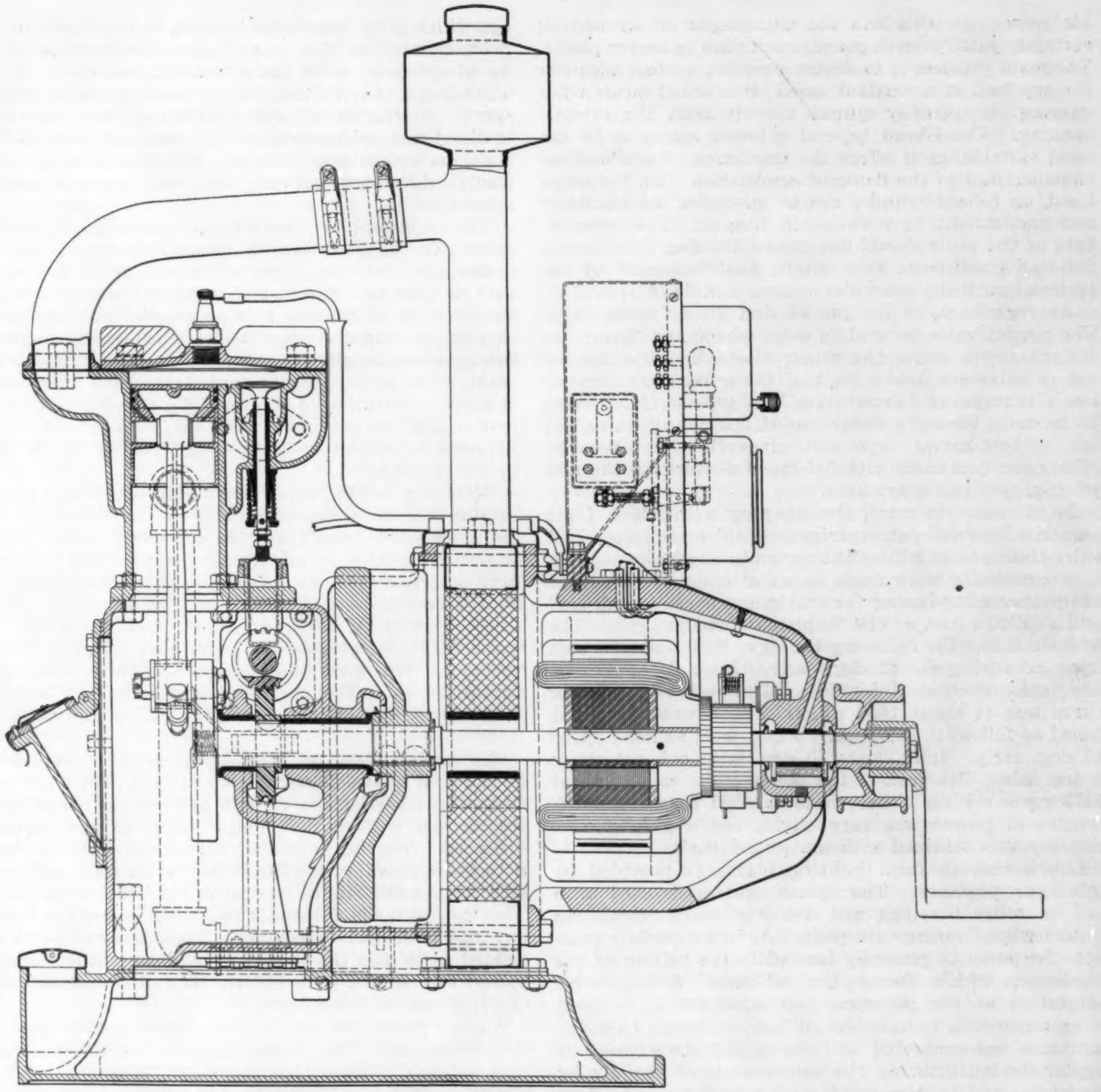


FIG. 14—SECTIONAL ELEVATION OF THE PLANT ILLUSTRATED IN FIG. 13

it is a 6 or a 12-volt starting battery or a 110-volt lighting battery it must be kept in operation just the same.

The plant must be fully automatic in its operation. It should start as soon as the battery reaches its lowest level and stop when it is fully recharged. It should also start automatically as soon as the load on the battery exceeds the charging rate and stop as soon as such loads are relieved. It must be designed to permit the use of the engine power to drive any needed accessories directly. It must be simple, reliable and fool-proof; a machine almost human in its operation. While the plant just described fulfills all the requirements of the average farm it can be made very flexible by increasing the size of the battery to suit conditions.

DESIGN FACTORS

The last phase to be dealt with is the one relating to the design of component parts. To be explained clearly, this subject must be divided into four parts; the engine, the generator, the switchboard and the battery.

A consideration of the design features of lighting-plant engines shows that no definite practice is adhered to. However, we find that the majority are of the four-cycle single-cylinder vertical type; four cylinders are used for the larger plants. Over 90 per cent of all farm lighting plants are direct-connected to the generator; belt-driven units are disappearing rapidly.

Regarding cylinder design, we find both the air and water-cooled type or a combination of the two. The latter is a happy compromise, as it permits a more complete vaporization of the mixture and a cooler-running engine. Water cooling is invariably of the thermosyphon type. With air cooling, a flywheel fan draws the air through the cylinder-head and cylinder and expels it outward. This cooling method seems to be limited to plants of 1000-watt capacity or less. There is no plausi-

ble reason for this and the advantages of air cooling certainly justify development for its use in larger plants. The main problem is to devise a cooling system adequate for any load at a constant speed; this would mean a fan varying its quantity output directly with the throttle opening. The I-head type of cylinder seems to be the most suitable, as it offers the least area of combustion-chamber wall to the flame of combustion. On the other hand, an L-head cylinder can be air-cooled satisfactorily and undoubtedly be made much simpler. The temperature of the walls should not exceed 325 deg. fahr. under full-load conditions; this entails heat-treatment of the material until the molecules assume a state of rest.

As regards valve design, we find almost every type. The poppet valve is used in every shape and form; the Knight sleeve valve, the rotary sleeve and the tapered rotary valve are used. Each of these valve mechanisms has advantages and drawbacks. The general trend seems to be more toward greater use of the poppet valve. It is the best-known type and gives the least trouble. Mushroom-type cams with flat-face followers are the rule when poppet valves are used.

In reference to cams, the company with which I am associated carried out experiments to determine the best valve-timing to suit the plant shown in Fig 13 on page 34. Two camshafts were made in an attempt to determine the proper valve-timing for maximum power at full load and at 1200 r.p.m. or 800 ft. piston speed per min. The first shaft had the following timing: Inlet opens 10 deg. late; exhaust opens 42 deg. early. Inlet closes 35 deg. late; exhaust closes 5 deg. late. The peak of the power curve was at about 1650 r.p.m. The second shaft was timed as follows: Inlet opens 6 deg. late; exhaust opens 40 deg. early. Inlet closes 30 deg. late; exhaust closes 3 deg. late. The peak of the power curve was at about 1475 r.p.m. With either shaft at 1200 r.p.m., the difference of power was very slight, but a greater fuel economy was obtained with the second shaft.

Lubrication in farm lighting plants is provided by splash or pressure. The splash system is used with ball or roller bearings and a low-pressure circulating system when bearings are plain. As in automobile practice, the pump is generally located in the bottom of the crankcase, which forms the oil-tank. A suggestive adaptation of the pressure circulation of oil, without using a pump, is to have the oil-tank separated from the crankcase but connected to it by a ball check valve or similar device, utilizing the compression of the air by the piston on its downward stroke to force the oil to the bearings. The amount of oil used by a lighting plant having a circulation pressure system is minute. In a 1000-hr. test made with our plant, the oil was never changed; the only thing done during the test was to add slightly over 1 qt. of fresh oil. This test covered a period of seven months and represents about three years of ordinary use on the farm. Upon analyzing this oil, we found that crankcase dilution amounted to about 30 per cent; nevertheless the total wear on all parts was hardly measurable.

The battery system is the prevailing type of ignition. However, most plants designed for export have a magneto. The reason for the use of a magneto is that batteries have to be shipped knocked down and are practically dead. So far as cost is concerned, the magneto compares favorably with the battery system, although the latter is somewhat cheaper.

A very interesting paper was presented by A. P. Young before the Institution of Automobile Engineers on the Process of Ignition, which states that the voltage which gives rise to the current in the short-circuited primary winding of a magneto is alternating, being produced by rotation of the armature; therefore, it is at a minimum at low speed, but increases in value with the speed. In the battery-coil ignition system, the voltage is direct and independent of the speed and is at all times equal to the battery voltage. This is the main fundamental difference between the two types of ignition apparatus.

The lighting-plant engine is essentially a constant-speed engine; therefore the battery system of ignition is the most suitable. Another advantage of this type is that its voltage is direct, which makes it possible to vary the duration of the spark to secure the best ignition of the charge. In the plant under consideration now the timing is set to allow the spark to cross the spark-plug points from 30 deg. before dead-center until 5 deg. after, or a spark duration of 35 deg. We found this gave the best results for power and economy, as a certain time is required to completely ignite every particle of gas within the cylinder.

Referring to the proper spark-plug position, I wish to substantiate the statements made by Captain Hallet that preignition can start from two oppositely located points in the combustion-chamber at the same time. When we first designed the cylinder-head, the spark-plug was located on the center line of the cylinder bore and, at full-load running, a disagreeable knock occurred. We reduced the compression ratio without results. Finally we moved the spark-plug toward the valve side, being careful to clear the bore of the cylinder, so that any escaping oil would not foul the plug. This eliminated the trouble.

Carbureters used on farm lighting-plant engines are of the well known float-chamber type or are plain mixing-valves based on the vacuum principle or operating in conjunction with a fuel-pump. Gasoline and kerosene are used. The float-chamber carbureter does not meet with the approval of the Fire Underwriters and will probably become obsolete as mixing-valves improve in design. They can be made automatic in operation and can handle any load with utmost economy. Their size can be so calculated as to hold the engine speed down without loss of power, in case the governor should fail to operate, thus averting serious breakdown.

Engine governors are of two kinds, mechanical and electromagnetic. The latter operate the throttle valve by a solenoid plunger, its movement being regulated by the rise and fall of the generator voltage.

Few manufacturers build their own generators. The four-pole design has almost monopolized the attention of American engineers because it seems to be the most adaptable type for the small sizes involved. Pole-pieces are laminated. The field coils have two or three separate windings, depending upon circumstances; a shunt winding, a series winding used only for starting purposes and sometimes a second small series winding to provide constant voltage irrespective of the load on the generator. In plants where no lighting battery is used, but only a small starting battery, the generator is duplex wound; that is, it has a special winding to charge the starting battery. While this tends to reduce the overall electrical efficiency of the generator, using power and light directly from the plant makes up for the loss through the use of the battery.

Real progress has been made lately toward the realization of a reliable fully automatic switchboard, but it is yet at best a very complicated and expensive piece of mechanism requiring an expert to keep it in running

order. Automatic control can be secured by two methods. One is based on the variation of the battery voltage or pressure; the other depends upon the actual capacity of the battery, its amperage or volume. The average switchboard of the semi-automatic type is very simple in construction and is generally composed of an ampere-hour meter registering the rate of charge and discharge and the condition of the battery at all times; a reverse-current relay combined with the starting switch, which keeps the main contacts together by electromagnetic action so long as the current flows from the generator to the battery and, when this action ceases, the contacts separate, the plant stops and the charging circuit is thus broken; and a line switch with a safety fuse. In some plants opening this switch eliminates all electrical load from the generator and all the engine power can be used as desired.

Storage Batteries

The storage battery is still considered the weakest part of the isolated plant. Much money has been spent by battery manufacturers to educate the buyer as to storage-battery construction, installation and care. The cells of a lighting battery are usually of the glass-jar type. Their capacity is determined by the work the battery has to perform. For lighting purposes only the battery should have a capacity of not less than 120 amp-hr. for the 32-volt system or 40 amp-hr. for the 110-volt service. When used for both power and light it should have a capacity of at least 160 amp-hr. for the 32-volt system or 60 amp-hr. for the 110-volt system. These ratings are according to S.A.E. standard; that is, they are based on intermittent discharge. Considerable difference of opinion still prevails as to which is the best battery-capacity rating, the S.A.E. standard or the 8-hr. straight discharge. While the former is better from the engineer's point of view, the latter is much simpler to express, although not so accurate. I merely record the facts and am at a loss to suggest any improvement.

The cost of a 110-volt set of batteries is approximately twice that of a 32-volt set of the same capacity. On the other hand, the loss of potential energy in the line circuit is much smaller in proportion with the 110-volt system. This calls for greater efficiency of the high-pressure type and, incidentally, when energy has to be carried some distance, the cost of the line for the 110-volt system allows a considerable saving over the line cost of the low-pressure type. Battery engineers have established the fact that the charging portion of the cycle of a lighting storage cell has the greatest influence on its life. Under normal working temperatures the positive plates disintegrate much more quickly than the negative plates. Deterioration within the positive plate is due to the loss of active material during the charging period and is known as sloughing. It is a gassing within the plates, producing small bubbles which result from the decomposition of the water of the electrolyte. In general, the slower the charge is, the better it is for the plates, although a high rate of charge is not harmful provided the temperature of the cell never surpasses 110 deg. fahr., which is the maximum charging temperature. It should be remembered also that a charging rate lower than normal causes sediment deposits and reduces the life of the battery. The same thing applies to an abnormally high rate of charge, but to a smaller extent. The best charging rate for the average lighting-battery set seems to be 12 to 14 amp. per hr. for a 32-volt 160-amp. set, and 4 to 5 amp. per hr. for a 110-volt 60-amp. set. As the generator furnishes constantly the same amount of watt-hours, the charge tapers off as the voltage rises.

So far as the best discharging rate is concerned, certain battery manufacturers claim that one-half the charging rate will allow the longest life of the battery. A high rate of discharge for short periods does not damage the battery, as seems to be the consensus of opinion, provided the normal section of the conductors is large enough to prevent overheating. It is not detrimental to discharge a battery completely so long as it is not allowed to remain in that condition. The best practice is to discharge the battery until its potential is just high enough to permit easy cranking of the generating unit. A lead-acid cell has a 2.2 to 2.3-volt e.m.f. when fully charged and a 1.7 to 1.75-volt e.m.f. when discharged.

Concerning the nickel-oxide battery more commonly known as the Edison type, this type of cell is used for farm lighting purposes in only a few instances. I understand that it will stand much abuse, but that it has a high charging rate and an overall efficiency of about 50 per cent. The Edison cell has a 1½-volt e.m.f. when fully charged and a 1-volt e.m.f. when discharged. This means that a greater number of cells are required for the same voltage; therefore, it is a more costly battery.

I hope I have made clear the importance of the farm lighting plant and its present position in the automotive industry. While I have not attempted to cover the subject from every angle, I have dealt with its most important questions and expressed my own opinions. In conclusion, I wish to emphasize that, while rapid strides have been made in the past, there still remains a great deal to accomplish as regards stability of design, reliability and economy.

THE DISCUSSION

H. Carlton:—Regarding the accessories which can be operated by the farm lighting plant, I believe they should be pushed by the farm lighting-plant manufacturers more than they have been in the past; also, that dealers should be persuaded to take on a full line of accessories and show the value of the electric generating plant from the standpoint of power as well as light.

H. D. Shamberg:—My experience has been mostly in the export field of the farm lighting business, which is growing very fast. The foreign customer usually prefers magneto-type ignition on any sort of internal-combustion engine. Perhaps this is due to prejudice against the battery-type ignition with the timer and coil, but I believe that the American automobiles which are selling so well abroad will overcome this prejudice, if it is a prejudice. The magneto-equipped plant is independent of the batteries and will operate even if the batteries become wholly disabled.

What is Mr. Froesch's opinion regarding the proper size of a plant for general use on a farm? It seems to me that if a small article like an electric iron requires 600 watts to operate it, a plant of say 750-watt generator-capacity would hardly be large enough for general farm utility; especially if more than one of these articles were used at a time and lights also were required simultaneously.

Charles Froesch:—I think the best size of plant for a farm is between 2 and 2½ kw. A plant of 1½-kw. capacity is a fairly good size, but it does not answer for the larger farms; it would be too small for general purposes. On the other hand, it would not be fair to design a plant to operate just one accessory or appliance that used 600 watts. The plant would be very inefficient, because a gas engine is not efficient when working under very light loads.

A MEMBER:—Are not most of the plants sold today of the smaller size?

MR. FROESCH:—Farmers are willing to buy a plant of larger size now. The tendency among them is to buy a larger plant even though it costs more. The larger plant has been demonstrated to them in a favorable light. Regarding the cost of the plant, the burning of two 25-watt lamps averages about 0.8 cent per hr.; using kerosene it amounts to 7 cents per kw., when kerosene is 18 cents per gal. With gasoline at 35 cents per gal. the price would be between 12 and 13 cents per kw.

W. H. YOUNG:—Why is there such a large difference in cost?

MR. FROESCH:—It depends upon what the price of fuel is per gallon.

A MEMBER:—Is depreciation included in that price of 12 to 13 cents per kw.?

MR. FROESCH:—No, that is simply the cost of the fuel. The battery is about the weakest link in the chain, as is apparent.

JOSEPH TRACY:—What is the power output of these plants per gallon of fuel?

MR. FROESCH:—About 500 watts; the consumption is about 1 qt. of fuel per hr. and the charging rate is 15 amp.

MR. TRACY:—You mentioned that some of the 75 different types of plant on the present market run without a battery; what is the approximate proportion?

MR. FROESCH:—Two plants are run without batteries; the remainder are all operated with batteries.

DR. RICHARD H. CUNNINGHAM:—Is the isolated plant adjustable with regard to the kind of fuel to be used?

MR. FROESCH:—When the machines leave the factory they are adjusted for gasoline, but there is an adjustment on the mixing-valve so that, by turning the valve, the plant will run on kerosene.

VOLTAGE REGULATION

C. M. MANLY:—I encountered the first isolated electric plants some 11 years ago when several companies were building 15 kw. and 25-kw. outfits for Army fortifications. They had to contend with the important matter of regulation. How closely is the voltage being regulated at present? The Government had very stringent specifications in connection with that between no load and full load. The tests that the generator and the entire outfit were put through in throwing them suddenly from full load to no load and back to full load were very severe. Voltage regulation was apparently the greatest trouble they were having at that time. Some companies seem to be producing outfits for commercial service that are perfectly satisfactory.

MR. FROESCH:—I am not in a position to throw very much light on that subject. On this little plant the only voltage regulator is a small series winding. I understand that some plants regulate their voltage with a solenoid plunger; that is, electromagnetically.

MR. MANLY:—How much voltage variation is there between no load and full load?

MR. FROESCH:—The voltage varies from 32 to 38 volts.

MR. MANLY:—How much voltage variation would there be on the 110-volt circuit? Have you built any 110-volt outfits?

MR. FROESCH:—No, we have not; but the difference must be greater because the National Gas Engine Association recommended that the plant must run to 125 volts at full load.

MR. CARLTON:—In building our isolated electric plants we have left off all governing arrangements; we have no special voltage control on the generator. We depend entirely upon the combination of the battery and the generator action to maintain the proper speed. We find that in this way we get approximately 2½ per cent voltage variation from no load to 25 per cent overload. In other words, it is a voltage variation that will barely give a flicker to the lights. We consider that this method has worked out well.

MR. FROESCH:—For export plants I advocate the use of a magneto because the battery is practically dead. However, if the total pressure of the battery is utilized there will be a sufficient potential to provide a spark for the engine ignition.

MICH E. TOEPEL:—Will the potential be sufficient for starting?

MR. FROESCH:—Yes.

MR. TOEPEL:—For what duration of time?

MR. FROESCH:—For a few short starts only. It depends upon the capacity of the battery.

MR. MANLY:—About the shipping of the batteries, what was the outcome of the proposition of shipping storage-battery plates fully charged and dry?

MR. FROESCH:—Some manufacturers did that, but they found that as soon as the plant was assembled the plates burst.

CARL F. SCOTT:—The great factor in the development of isolated plants was the tungsten lamp. It reduced the energy required to an extent that made possible a great amount of lighting from a very small engine and generator. A second great factor in pushing the business among farmers was the stress placed on "power" rather than on "lighting" features, because the possibilities are enormously increased by the use of power on the farm, as compared with the use of the light alone in the farmhouse.

With the larger plants, in connection with the increased cost of operation, is there not a tendency toward 110-volt plants that have only a starting battery and get along without a large storage battery? Have we realized the possibilities of increasing the speed, decreasing the cost and increasing the efficiency? Is the time coming when these plants can be run at full load, inside a room, so noiselessly that they would scarcely disturb a conversation? Regarding automatic control, is not the tendency toward a plant that starts up when the first device is operated and shuts down when the last device is turned off?

MR. FROESCH:—There are only two batteryless plants on the market now. They do not seem to be very popular with the farmers. One of the main troubles is that sometimes they start and sometimes they do not.

With regard to noise, lighting plants are continually being made quieter. This plant is somewhat noisy because it is hand-made and not a straight production job. We have made only about 17 machines of this type, and do not expect them to run very quietly. The fact that a plant has a higher speed does not decrease the cost of the plant. It must be made more accurately. It seems that the lower-speed plant prevails on the market. I believe in the high-speed plant, but it seems that the majority of the plants today run at 1200 r.p.m.

Regarding automatic control, very few such plants have been placed on the market. There is a tendency toward plants that start automatically, but sometimes they do not start, as I have said. A reliable automatic switchboard has not yet been designed, although it is the proper thing. Such a switchboard must be simple, because simplicity means reliability. It is hard to get, but we are coming to it. It must be remembered that this

type of installation is very young. We have been working hard on it. Previously such plants were simply makeshifts. No research work was done along this line until the last two years. A great many plants have been manufactured lately.

Controlling Devices

MR. SHAMBERG:—With reference to the full-automatic feature, it is a disadvantage to have a plant too completely automatic, because the owner is not likely to give the plant sufficient attention. The semi-automatic plant which is started merely by pressing a button can be designed with the starting switches at remote places. For instance, a second starting button can be put upstairs in a house, if the plant is in the basement.

MR. FROESCH:—I believe that one manufacturer puts out a meter which starts the plant automatically as soon as the load is greater than the rate of charge of the battery.

MR. CARLTON:—We watched the automatic system for some time and found that it involved considerable delicate apparatus which necessitated repeated inspection by persons who knew the apparatus. As a result, we produce a non-automatic plant that is started by the battery after pushing a button and stopped by a push-button also. We followed that practice to reduce the plant to the simplest form. We felt that it would be a safer plant to put into the hands of inexperienced persons; that there was a better chance of its being properly maintained. We do not see that it is necessary to put an automatic stopping device on an electric generating plant, any more than on an automobile starting and lighting equipment. The conditions are the same in every way.

MR. FROESCH:—The automatic feature of the ampere-hour meter is good. It is very reliable, and it eliminates the human element. It is possible that the farmer will run the plant too much and overcharge the battery.

MR. CARLTON:—The protection that we have installed is in limiting the amount of fuel. The operator can fill the tank full of kerosene, start up and let the plant run until the fuel is gone. We think that is a fairly safe feature. No expert inspection is necessary.

MR. FROESCH:—How can the exact condition of the battery be determined?

MR. CARLTON:—We believe the only proper way is by using an hydrometer.

MR. FROESCH:—We recommend that users examine the condition of the battery with an hydrometer monthly, and from that reading check up the ampere-hour meter. It can be done very easily.

W. S. BOULT:—One firm guarantees its meters to be electrically correct for one year. During the year, if anything happens to the meter, the customer need only take it off and send it to the factory. The same would apply at the end of the year; there is no charge for testing it.

FRED W. ANDREW:—We should understand that in charging the battery and discharging it there is always a loss. I had something to do with the Delco system in the early days and we took this loss into consideration. I think the instruction book said that the ampere-hour meter was to be checked up with the battery by using an hydrometer about once monthly. I fail to see how that condition could change.

MR. BOULT:—On the base of the ampere-hour meter we have a resistor that can be set for rates for overcharge of the battery ranging from 10 to 20 per cent.

MR. ANDREW:—One can charge the battery at a certain efficiency, but in discharging it one never gets out all that has been put in. Of course, the ampere-hour meter cannot take care of that ordinarily. Is there some device which automatically takes care of that discrepancy? As I see it, that must be set from an hydrometer reading at frequent periods.

MR. FROESCH:—The charging and discharging records from the ampere-hour meter are not the same. The needle travels 20 per cent more slowly on the charge than on the discharge. That is the reason we advise the monthly calibration of the meter.

E. J. BARNEY:—The resistor is a device used for keeping the ampere-hour meter in step with the battery so far as is possible but, over the wide range of load that it operates, there will be a slight error at about the end of a month. We take care of that by asking the user to charge the battery fully and to set the hand of the ampere-hour meter in the proper position once monthly.

A MEMBER:—I had my first intimate acquaintanceship with the isolated charging plant last summer. I found a battery in a country store that needed to be cleaned. The sediment had accumulated so that it came almost up to the bottom of the plates. Is the depth of the battery cells made sufficient to take all the sediment or, in general, must the battery be cleaned before the plate's life is entirely gone?

MR. FROESCH:—The battery should be inspected regularly.

MR. ANDREW:—The Koehler plant has a small four-cylinder engine and it operates by turning on or off whatever device one wants to use. The only battery used is a 24-volt battery for starting purposes, but this does not carry the load. Whether it operates well, I do not know.

In regard to ignition, you stated that the battery-ignition spark was on for 35 deg. Do you mean that the spark continued 35 deg.?

MR. FROESCH:—Exactly.

MR. ANDREW:—You do not mean that the build-up of the coil is for 35 deg.?

MR. FROESCH:—No, the duration of the spark is for 35 deg. in the plant.

MR. ANDREW:—How do you obtain that?

MR. FROESCH:—With a coil; it is a succession of sparks.

MR. ANDREW:—Do you use that vibrator continuously?

MR. FROESCH:—We use it for 35 deg.

MR. ANDREW:—Is it used like the old Ford vibrating coil?

MR. FROESCH:—Yes.

MR. ANDREW:—Do you have any trouble with the vibrator?

MR. FROESCH:—We have no trouble whatever.

MR. ANDREW:—Why is a water-cooled engine used for this work? When the Delco lighting system was first put out, we went over air-cooled and water-cooled engines very thoroughly. We concluded that a lighting system of this kind was likely to be installed in places where freezing might occur in winter. That is why Delco used an air-cooled engine, and why I am personally in favor of an air-cooled engine for that type of apparatus. If Mr. Froesch favors an air-cooled engine, why does he show a water-cooled engine?

MR. FROESCH:—Engineers are choosing the path of least resistance and such is the case in this instance. The air-cooled proposition is better, but it requires more research work.

MR. ANDREW:—I think there is no question that the air-cooled engine is about to come into its own, because of the scarcity of fuel and the fact that it can be run with greater efficiency than a water-cooled engine. I

have never been able to make up my mind that the 32-volt system is right. One can buy apparatus for the 110-volt system anywhere in the country.

THE 32 AND 110-VOLT SYSTEMS COMPARED

MR. FROESCH:—The 32-volt system is pretty much standardized in the country now.

MR. ANDREW:—It surely is not standard in foreign countries. A number of Delco lighting plants were shipped to South Africa. Battery supply houses are scarce there. That is one of the reasons exporters prefer a magneto on the engine.

MR. FROESCH:—The first plants made were 32-volt; they included only a plain generator, a set of batteries and a switchboard. Why the battery manufacturers who made the plant chose that voltage I do not know, but it was the most popular type at that time.

MR. ANDREW:—I am not particularly in favor of 110 volts, alternating current, but what are the objections to a 110-volt 60-cycle alternating-current system that is direct-connected to a gas engine?

MR. FROESCH:—I am not in a position to answer that question.

MR. SHAMBERG:—I believe the reason for the 32-volt system is the initial cost. It requires only a 16-cell battery, whereas the 110-volt system requires a 56-cell battery. The latter would cost considerably more.

MR. ANDREW:—That is true, but batteries are not necessary. Should we or should we not use the 110-volt system?

MR. SCOTT:—I agree with Mr. Andrew. A 20-hp. engine and starter, a battery and accessories can be bought for about $510. The system described here costs about $645. Why is it not possible to have a system capable of more than ½ kw. without batteries and without more than the most rudimentary type of switchboard? Two years ago I made a lighting system for a country house. I used an air-cooled motorcycle engine and a small generator. About 11 p. m. we would shut off the switch. It ran for two summers. I suppose it had intelligent care, compared to the ordinary powerplant maintenance on a farm. It cost about $150, but perhaps would have been too crude to meet the ideals of the modern farmer.

There seem to be distinct possibilities in a 110-volt 60-cycle alternating-current light and power system operated without a battery. Such an equipment would use an 1800-r.p.m. single-cylinder engine fitted with a starting motor, generator, battery and switch of about the type used in a Ford automibile, or even smaller. The entire combination of generator, starter, battery and switch for this car can be obtained today for about $85. Thus the starting and excitation features would be a small item in the total cost. Such a generator and starting battery would be ample for exciting the fields of the alternating-current generator, which would be of the synchronous type. The generator could be constructed at a lower cost than the present direct-current generators, and the equipment would have the advantage of utilizing standard 110-volt lamps and devices and standard small 110-volt alternating-current motors, which have been developed to a very great degree of efficiency for all classes of work.

The only problems then connected with this system would be those of voltage regulation and automatic control. With the separately excited field, the problem of voltage regulation for varying loads would be no greater than that experienced on an automobile lighting generator at varying speeds. Granted a reliable starting and stopping switch for putting the plant into service when the first device is turned on, and stopping it when the last light or motor is turned off, we have a system that should be materially lower in first cost than those now offered; one entirely lacking in the objectionable features of the large battery; one adapted to transmit power greater distances without too great a relative voltage drop; and one using devices applicable to any standard power service equipment. Farmers would be more ready to install such systems, because of a realization that when central-station power came to their district at a later time, a large part of their own electrical installation would still remain standard.

MR. YOUNG:—When generator sets are manufactured in quantities comparing with the production, for instance, of the Ford motor car, I think they can be produced at a much lower cost. The present price, however, is comparable with that of other apparatus built in the same quantity.

O. A. ROSS:—Referring to the suggestion just made to employ 60-cycle alternating-current generators, it must be remembered that the field of these machines is separately excited by a direct current. For this reason, a direct-current generator or a storage battery would be required. In the latter case a generator would be required to charge the storage battery. It is necessary also to regulate the field current with any change of alternator load; this, of course, can be done automatically. It seems to me, however, that in place of simplifying, the use of alternating-current generators adds complications to the isolated electric-lighting plants under discussion.

ELMER H. SCHWARZ:—Probably those who have spoken in favor of doing away with the batteries have forgotten that the average farmer does not run his plant all the time; the battery is needed to supply lights when the generator is not running. In case of a shutdown of the gas engine, the batteries are in reserve. I think that is the main reason batteries are used. One of the possible explanations of a 32-volt system is that train lighting had come to 32 volts, after a try-out of 80 and 60-volt systems. On account of this experience, undoubtedly, the 32-volt system was found to be the most practicable, mainly, I suppose, from the standpoint of the storage battery.

HENRY C. MCBRAIR:—In reference to the alternating-current system, is it not a fact that the General Electric Co. built a compact three-phase machine, and a type "D" machine called a "compensator" which had a small combination generator and alternator for exciting it; but that it abandoned them about eight years ago, and then used a separately-excited direct-current machine, which required an extra-small generator on the end of the alternator? I should say that this would be too complicated a proposition for a farm.

MR. ANDREW:—I think Mr. McBrair has answered the question. It is not a very difficult matter to build a separately-excited generator of small size and constant speed which can be used for farm lighting. To make it fully automatic, it seems to me that the final article in this line would be an air-cooled engine with possibly a 110-volt 60-cycle alternating-current generator.

MR. BARNEY:—How will the voltage regulation be provided for on the alternating-current unit that has been suggested? It will mean the addition of some complicated mechanism, such as a Tirrell regulator. Anyone acquainted with alternating-current machinery knows that such a regulator is used in powerplants for regulating purposes.

JOSEPH A. ANGLADA:—Farm lighting maintenance resolves itself into the same proposition that we have with automobiles. We buy an automobile and for perhaps the

first two months we take care of it regularly; during the second two or three months we devote less attention to it; finally we decide that the car needs no attention. With the farm lighting outfit, the farmer puts the machine down in the barn to avoid its noise. The farmer with the non-automatic outfit finds it troublesome to go out and shut the machine off. We know that the two-cycle engine is a cheap one to build. It seems to me that a 110-volt, automatic, non-battery system is what we shall use eventually, just as we have adopted simplicity in automobile construction.

MR. FROESCH:—The question regarding the use of the two-cycle engine for lighting plants is very logical but, if we wish to use the plant to charge the batteries and also have a sufficient capacity to operate small appliances, the charging load will be very small compared to the full load, and it is well known that with a two-cycle engine it is too severe. You must make it small, so that the charging load will be high enough to permit good scavenging of the cylinder.

MR. CARLTON:—With a 110-volt system or with any other system without a battery, how will night-light conditions be met, such as a few lights for all-night service or a bathroom light? Without the battery, we must keep the engine running all the time we want light. With a battery this is taken care of.

MR. ANDREW:—It is already taken care of. The machine has to run, it is true, but it can be shut off at any time, right in the house, and without having the battery system carry the load.

FUELS

H. H. BRAUTIGAM:—Will Mr. Froesch inform us regarding his fuel problem? We have not yet made a perfect-running kerosene engine in the automobile or in the marine field. In the automatic and isolated farm lighting systems, we have a semi-loaded condition. We can operate on fuels which cannot be used in the automobile field, such as kerosene. Will the different outfits that are being put upon the market to run on both gasoline and kerosene be successful in the long run, and will they give satisfaction to the purchasers? We know that kerosene requires special means for vaporization. We must contend with carbon in the cylinders, dirty spark-plugs and more or less unburned fuel going down past the piston and collecting in the base of the engine. Every lighting outfit on the market today is put out to run on gasoline. All claim, however, that the outfits can be run on kerosene. But this requires a different adjustment.

MR. FROESCH:—The Delco plants have been very successful in using kerosene for fuel during the last two years. We have been using kerosene to a great extent, and we have found less carbon deposit with it than with gasoline. The carbon deposit we had with kerosene was gumlike; what we had with gasoline was solid. I cannot explain readily why this happens. I have not had time to investigate it. But it is a fact that we find the plant will run more successfully on kerosene than it will on gasoline.

WILLIAM E. KEMP:—Our experience has been that under certain conditions kerosene can be used as successfully as gasoline. It is my opinion that the single-cylinder engines used for isolated electric generating plants most nearly approach an ideal condition, principally because we can use the heat generated by the engine to better advantage, and also avoid the difficulties usually encountered in multi-cylinder engines wherein long intake manifolds are needed.

I have done some experimental work with heavy fuels and have found that with thorough mechanical vaporization of the fuel by vacuum, aided by sufficient heat closely applied to the inlet port of engine and with the fuel nozzle located as closely as possible to the inlet, or approximately 6 to 8 in. from the combustion-chamber, kerosene develops more power and is more economical than gasoline. This result is undoubtedly due to utilizing the greater number of heat units contained in kerosene.

There are numerous methods of applying heat to the mixture but, where the design has permitted, we have invariably obtained a higher efficiency by using a form of intake manifold, integral with the exhaust, that has caused the heavier particles of fuel to be impinged and retained against hot surfaces, and also permitted the lighter particles to be carried to the combustion-chamber at a lower temperature, thereby decreasing the volumetric losses due to expansion.

H. W. SLAUSON:—The sales possibilities of these plants are not limited to the farm. I do not live on a farm. I pay 12 cents per kw. for electric light. If I could get it for 9 cents, I would consider buying one of these isolated plants. Many people in this country have summer homes where such plants can well be used; at the seashore, the mountains or on small private estates. We should have a name for a plant of this kind that is more comprehensive than "farm lighting plant" or "farm powerplant," one that indicates its possibilities as a producer of power and light for every kind of house or service situated too far distant from the main power-current source. Regarding the power take-off on this particular plant, are there many conditions where it is better to use the power take-off than an individual electric motor?

MR. FROESCH:—Whenever it is possible to use a direct power take-off, it is advisable because it is not necessary to use batteries. Battery efficiency is between 75 and 85 per cent, but is about 75 per cent in most cases. I advocate the use of batteries for light and for small household appliances such as electric irons, but whenever an electric motor is needed a power take-off is more economical if it can be used.

MR. BARNEY:—In sections producing natural gas, I think most farm lighting plants could be operated on natural gas. In West Virginia, Kansas and Oklahoma natural gas can be obtained at from 20 to 30 cents per 1000 cu. ft. The average unit might, I think, be expected to deliver between 25 and 30 kw-hr. per 1000 cu. ft. That would cut down the operating expense.

E. FAVARY:—Does Mr. Froesch recommend any changes in the design of the engine when kerosene is used as fuel?

MR. FROESCH:—The main feature in this engine which is different from the automobile engine is the use of a bell-crank type of shaft. The connecting-rod follows standard design and so does the remainder of the engine. The only difference probably in this engine between gasoline and kerosene for fuel is that the head is air-cooled, resulting in vaporization. I think it vaporizes kerosene just as well as it does gasoline.

SERVICE

G. W. WARD:—I have sold many farm lighting plants and recently have visited the factories of many different manufacturers. Service is one of the biggest problems that the farm lighting industry has to contend with. These plants are placed on farms where they will be stationary and it will not be easy to give them attention. It is well worth while to begin right now thinking along

that line. A plant must be as nearly fool-proof as possible. These plants are going into isolated places. They will be forced to function under all kinds of conditions. Last fall I traveled 700 miles through Maine and found many farmers who had installed isolated plants but gone back to kerosene lamps. Many of the plants were of good design; others were of the old belt-driven hand-regulated type. The trouble was that the plants had not been serviced and the men who had sold them had left the district. No one manufacturer was to blame; half a dozen different firms were responsible for the condition. Later I was told that the manufacturers could not afford to render service. I found the same problem in another locality. We must standardize. Service must mean a certain thing; today it does not in the minds of the distributor and dealer. If the isolated-plant manufacturers will agree on what constitutes service and what their guarantee is to be on a plant, stick to it and insist that dealers and distributors do the same, we will eventually have the condition of a distinct class of men servicing plants in rural communities. Then the big problem that is retarding the industry as much as any one thing will have been solved. Many dealers are obliged to give up the sale of isolated plants because attempting to keep the plants in operation would take away a large part of their income.

C. W. DEAN:—The chief trouble with farm lighting plants is that the majority of salesmen sell the farmer too small a plant for the work desired or required by the farmer. The salesmen, eager to make sales, will guarantee service for one year and guarantee other matters they will not be able to live up to. In other words, they guarantee the farmer an engineer for one year. The word service has been much abused. No manufacturer can sell an isolated electric plant for $645 and guarantee an engineer to maintain the plant for a year.

A full-automatic electric-lighting plant without batteries is impossible with present inventions. A full-automatic electric-lighting plant wth a starting battery only is possible, but it is not satisfactory at present. The addtional cost of copper for installation must be considered. It would cost practically as much to run one light as it would to run 10 lights. The engine would be running to use one light just the same as it would for several lights. This would require starting up the plant often, waste fuel and use the automatic electric starting devices beyond their capacity or guarantee. It is no more possible to have a full-automatic electric-lighting plant without batteries, than it is to have a telephone, telegraph or wireless system without them. It is a known fact that all these systems have both batteries and generating sets.

Referring to a demonstration I saw in North Carolina, a plant had a 12-volt starting battery with a return wire run from each light back to the battery. When a light was turned on, the automatic cut-in would connect the generator with the battery and start the engine running. A 20-watt light was used and 15 of them were on one circuit. The negative wire was run the entire length of the lighting circuit to the main-line switchboard. There was a wire from each light to the positive side of the battery, thus making 15 return wires to the battery. I was the lowest bidder by $700 on a lighting plant for a building. I submitted proposals on a 3-kw. system with a 56-cell battery. One of my competitors submitted proposals on a 1½-kw. full-automatic plant, using a 12-volt starting battery.

MR. YOUNG:—Regarding the size of the isolated plant, I agree with Mr. Froesch that we should endeavor to make it 1½-kw., with an overload capacity so that certain extra appliances can be connected. The greatest difficulty in that respect has been that, with a small plant for lighting, the owner loads it up with curling irons, fans, smoothing irons and other additional electrical apparatus, and immediately gets into difficulties.

MR. BARNEY:—Concerning the life of the isolated plant, even more than five or six years of service can be expected of them. I know of some units that have been run between 17,000 and 20,000 hr. on test. Compared with the life of an automobile in actual running hours, this is very favorable. Allowing 10 hr. running time for a plant per week, the life of a plant should be much longer than five or six years, as Mr. Froesch's experience indicates.

MR. FROESCH:—The battery wears out in four or five years sometimes, but I have known instances where they have lasted 10 to 12 years. This depends largely on maintenance. With good care, the battery will last probably as long as the plant, but in the majority of cases the battery must be replaced before the plant.

LOW-TEMPERATURE DISTILLATION OF COAL

By low-temperature distillation of bituminous coal is meant distillation at a temperature around 1000 deg. fahr. When distilling at this temperature a very small amount of gas of high calorific value is generated and a large quantity of tar with a small amount of ammonia. This process has been demonstrated on a practical scale by different investigators in this country and abroad. It has been definitely determined that from 20 to 30 gal. of tar can be obtained from 1 ton of bituminous coal, something like 12 lb. of ammonium sulphate and from 1 to 2 cu. ft. of gas and about 75 per cent of coke.

The tar from this process contains considerable quantities of engine fuel and creosotes. It has been estimated that it would be possible by the splitting up of this tar to obtain from 15 to 20 gal. of engine fuel per ton of coal. Investigations indicate that in a crude state this tar is worth in the neighborhood of 10 cents per gal.

The coke from this process would probably contain from 12 to 15 per cent of volatile matter which would contain most of the nitrogen originally in the coal. By gasifying this coke in the by-product gas producer, from 50 to 85 lb. of ammonium sulphate will be obtained per ton of coke gasified, and from 65 to 70 cu. ft. of gas having a calorific value in the neighborhood of 140 B.t.u.

The low-temperature process will yield by-products having a value of from $2 to $3 per ton of coal gasified. By gasifying the coke in the by-product gas producer the ammonia recovered will have a value of from $2 to $4 per ton of coal gasified, depending upon the amount recovered. In other words, by combining these two processes, by-products having a value of from $4 to $7 per ton of coal gasified can be obtained.

The low-temperature distillation of coal can be carried out in cylindrical retorts and discharged into the producers. A combination of the two processes will result in a mixed gas having a calorific value of about 150 B.t.u. per cu. ft. There are other advantages in the combination of the processes such as the simplification of the scrubbing of the producer gas due to the fact that 95 per cent of the tar comes off in the low-temperature distillation.

The market for the by-products obtained from these two processes is an increasing market. A large portion of the tar by-product can be used for engine fuel.—C. M. Garland in the *Journal of the American Institute of Electrical Engineers.*

Cooperation of the Automotive and Oil Industries[1]

By C. F. Kettering[2]

I AM delighted to have an opportunity of attending some sessions of this Institute. I had to leave the meeting this afternoon; I felt so corry for the petroleum industry after I heard the Doherty-Welch symposium about how hard up they are that I just got crying and had to leave the room. I understood that Welch finished the thing up by saying it is difficult to get blood out of a turnip, but that they are going to do it if possible. I have been wondering since who the turnip is. Representing some 8,000,000 users of petroleum products, and looking from the outside in, you know we have an idea as to who the turnip is.

Your president seems to have a little antipathy toward this curve business. I am here to tell you there are about 7,000,000 people outside of the petroleum industry who have never got onto the oil fellows' curves yet, and so we appreciate what he means when he says he does not understand curves. You have public opinion against you; rightfully, too. If the petroleum industry ran for president, it would be worse than it was this last time.

Here is the reason public opinion is against you; you talk about the newspaper fellows and all that, and what you say is true, but what has the petroleum industry done to educate the public as to what it is? If I were setting a little task for the petroleum industry to perform for the benefit of themselves and every consumer who drives an automobile, I would have you give out data not such as you gave out this afternoon, but say that for every gallon of oil you produce you only make a cent. I would not tell how many gallons you produce, though, because then you would get in jail sure. I would get the statistics out in a simple elementary form consistent with the imaginative ability of the average automobile driver, so that he could understand them, and every time that a man got his automobile filled at a filling station I would give him a receipt for the money that he paid on the back of which would be something about the oil industry. Now that is your newspaper. Your filling stations are your newspaper distributing agencies, and if you do not do that you will have all this government regulation, because everybody is against you, and I am going to tell you why before I get through. You deserve it.

In our town the filling stations range architecturally from Japanese pagodas to every other kind of thing in the world, and the owners will not hire any young fellows to run them, because they overflow the pumps and give you about half a pint more than you pay for. Anyone who is talking of the great scarcity of oil and then goes and looks at the filling stations that are established all over this land, can but wonder. "They must have a lot of money. They couldn't run them if they didn't." You just naturally feel that.

I feel a wonderful responsibility in representing 7,000,000 people here tonight, and I will try to tell you how one of the 7,000,000 feels, because the rest feel worse than I do, and because I know some of you fellows and that you are not as bad as they think you are.

The only cloud on the internal-combustion engine field today is the fuel supply. I think it was Mr. Doherty who said that he would guarantee for this generation, and the next generation and the next generation afterward that they will have an adequate supply of gasoline. Now, you know, the average user would like to know what gasoline is. That is a pretty serious question, and I am willing to bet that there is not a producer in this organization that uses the fuel which he sells in his own car. There are thousands of automobiles being laid up today because we cannot get them started. I get blame for that because we make self-starters, and it is not that at all. So I have a lot of trouble over this oil business.

The production of fuels today has a number of interesting phases. We have been increasing the demands for your product. You started this business out by making kerosene, and then you had to get some government regulations to keep you from putting all the gasoline into the kerosene and blowing the kitchen lamp up. Then the internal-combustion engine came along and took that by-product away from you, but they have never passed a rule the other way, to keep you from putting the gasoline in the kerosene and the Government still keeps these oil inspectors at your refineries. I was down at Baton Rouge at an oil refinery and a fellow was inspecting the kerosene to keep them from putting the gasoline in it. I said, "That is the funniest thing I ever heard." They said, "Oh, he never comes down. He has a colored fellow who stamps the numbers on the ends of the barrels."

High Fuel End-Points

To meet this fuel supply we have gradually increased the end-points of our fuel to the point where we have got into trouble. There are three fundamental problems that the automotive industry is facing. The first is the fact that as the gravity goes down, or the end-point goes up, we have more difficulty in vaporizing the fuel, which I think we can prove has nothing to do with the burning side of it; but it has much to do with getting the proper distribution in the cylinders. In other words, as the fuel is atomized it condenses on the sides of the manifolds and naturally runs along the edges, and the cylinders at the end will get more than those in the middle, where it is taken from the open manifold. We have the question of distribution; that is helped out by heating the manifolds, but not to the extent you think, as Dr. Dickinson has shown by moving pictures. The first big problem we have in the design of engines today is that of distribution. We realize just as well as you do that to raise the gravity of the fuel to where it used to be would not be economical from many standpoints. There is a common ground on which the distribution can be worked out satisfactorily. We have not exhausted all of our resources in the automotive industry yet.

[1]From an address delivered at the meeting of the American Petroleum Institute held at Washington, Nov. 17-19, 1920.

[2]M. S. A. E.—General Motors Research Corporation, Dayton, Ohio. Mr. Kettering was a delegate of Society and the National Automobile Chamber of Commerce at the meeting.

Following that comes another difficulty which is not generally known and which causes an immense amount of trouble, and that is the fact that the non-vaporized fuel which goes into the cylinder passes the piston-rings, and we have what is known as crankcase dilution; that is we thin the lubricating oil. When we thin the lubricating oil we dissolve it on the piston walls and we blow through some of the burned vapors and they condense and we get water in the bottom of the crankcase. The water freezes in the winter and we twist the shafts off. We have had some very learned men in the oil business who have said there is no such thing as crankcase dilution. Of course that settles it. But, nevertheless, we have it. In fact, the great difficulty we have is that people come around and say, "Why is it that I do not have to use any oil in my engine? It makes oil. I start out with it half full, and in two weeks it is full." That is really a serious question. The oil refiners say that that is because we do not fit our pistons and cylinders, and so on; part of which is true and part of which is not, because the best engines we make still have a large amount of crankcase dilution.

There are a few things that we must tell the public, things that the public ought to understand; why they have crankcase dilution, why they have this and that difficulty, and it is up to the automotive industry and you to tell them in a simple way so that they can understand. If people understood the real fuel problems and the real difficulties today, we could get them to do the things that are essential to overcome those difficulties to a certain degree. Now all they do is to berate the oil refiners for selling them bad fuel and blame us a little for not making our automobiles any too well. There is some truth in both of those accusations. Those two problems have to do with the end-point or the volatility of the fuel.

There is another thing which has to do with production. This afternoon as I listened to the oil men talk and assure us in their optimistic way about the wonderful supply of the future, they were all trusting to the Lord to get it for them. That is the thing which worried me, because I know a lot of them and that is the first time I ever knew them do that. The only thing they talked of in connection with the oil business was consumption. Production was all right; it was the consumption that was wrong. We were getting the production all right, but we were using too much of it.

As you bring the end-point of our fuels down we have another side to this question, which is the chemical side; and as you lower your gravity and you raise the end-points you are forcing the engine builder to lower his compression. As you force him to lower his compression the demand for fuel goes up because his engines run more inefficiently; the more inefficiently they run the more fuel he needs, and the more you must raise the end-points the more he has to lower his compression. It is just a question of time.

Chemical Phases

If we ever hope to solve this problem we must recognize that we are not interested in the millions of barrels of fuel produced per day, but in a much smaller matter than that, the molecular structure of the fuel and what we can do to help in that very important matter. It was about 300 years after the discovery of gunpowder before anybody had time to question whether that gunpowder and the gun were best adapted to each other; and they used to make the breeches very thick, and so forth. They were too busy shooting up people with what they had to inquire whether it was the best thing. I do not believe that there have been very many serious thoughts given to the question of the adaptability of our present fuel to the gas engine. It came in as a by-product, and it has been a buy-product ever since, and we have done the buying.

For only a few years have we been able to put indicators on gas-engine cylinders to measure waste. It was only a short time ago that they put indicators on the breeches of guns and found out that the growth of pressure with the old powder was just the reverse of what it ought to be, maximum pressure at the breech and minimum at the muzzle. Wonderful improvements have been made in artillery. The whole internal-combustion engine business is nothing but a species of projectile work in which we put the same bullet back in the gun every time we shoot it off.

With all due respect to the fact that your president took several very indirect slaps at the scientific side of things, if there is any one thing that is lacking in the petroleum industry today, it is intelligent science. I know the kind that he is talking about. He wants something that is seasoned a little bit. We believe in that, too. Nevertheless, we feel that there is a condition growing up here. We have talked about this to a great extent with the automotive engineers, and they have not bothered with the fuel question because all they have had to do was to build the engines. The fuel producers are not interested in the engine business; all they have to do is to sell the fuel. So this problem has been thrown out in the middle of the road, so to speak, and has been nobody's responsibility.

This organization, I think, is the first body in the history of the world that has made it possible for the automotive industry to talk about the fuel end of the matter. So that this is really a constructive meeting because it brings together our two wonderful industries. You say, "Our fuel must be all right, because people keep on buying it." I could not help but be amused this afternoon when one of the gentlemen spoke about the price of spring water which was 25 cents per qt., 15 miles from the source of supply. You know you do not have to drink spring water. You can get rain water if you want it. But it is altogether different with the fuel. Some of us live in such a modest way that we do not have to drink spring water. It is a fact that people have to take the fuel which is given to them without an understanding of why it is that the matter has got into the condition it is in now; so that for the first time, as I have said, we have the fuel industry brought into contact with the automotive industry.

Perhaps in the earlier days of your lives you debated in some country schoolhouse on which is the greatest civilizing influence in the world, the pen or the sword. I do not think that either of them has done very much. Horsepower has been the civilizing influence of the world. Just in proportion that men have been able to use power externally from themselves has civilization advanced; and the internal-combustion engine has been the greatest civilizing influence the world has ever had, for the reason that it is the first detached power unit we have had which has not had to run off a public service line, or something of that sort, and which a fellow could take out and do what he pleased with, load it up as he wanted to and run around over the country at will. We have supplied that which was mentioned this afternoon, the power to cultivate acres of ground, to produce food where otherwise it would have to be consumed by animals which furnished the horsepower. Petroleum, the liquid fuel side of the question, is the most important thing in the world today, and

the development of civilization, up or down, as it may go, will depend more upon the industry you represent than upon any other thing in the world. Abroad today the fuel question is a most serious one. In this country it has been more or less serious. On account of traffic conditions last year the coal question became serious, and we only realized to what a tremendous extent civilization depends upon horsepower. We look at an electric light and never think of the powerplant and the enormous amount of equipment back of it. We use power in various devices, our steamship lines, our railroads, our automobiles and our airplanes, all of which are today at the basis of future development and all civilizing work. This is something to be studied in the most serious way that men can study. Any amount of money that the automotive industry or the American Petroleum Institute may expend in solving apparently elementary problems connected with the internal-combustion engine will be repaid in the fruits of such research work manyfold.

Compression and the Fuel Problem

We have it on good authority that if we took 10 per cent of the heavier ends out of our fuel today, we could run more economically than we do now. We cannot burn the fuel sold at the average filling station today in a high-compression engine, such as is installed in an airplane. We cannot fly. It is almost impossible to get off the ground if we have to fill our fuel-tanks with ordinary automobile gasoline. The reason for it is that we get that awful knocking in the engine. With a compression of 125 lb. per sq. in., if we open the throttle to get two-thirds or three-quarters of the maximum power, the explosions become so intense that they just cave the piston-heads in. That, gentlemen, is the real fuel problem. We cannot raise the compression of our engines, because if we do, when we open the throttle wide, or when the engine gets a little dirty, the engine pounds so hard that it will fracture the porcelains in the spark-plugs, and will break down the bearings. When we lower the compression to the point where we can open the throttle wide and not subject the engine to undue strains, we work but very little of the time at that demand. In other words, the percentage of the total time that an automobile engine is asked for full power is very small; we must drive that engine along at 20 or 30 m.p.h., when the throttle is very nearly closed, and the compression is dropped down to maybe one-third or one-quarter of maximum; and we burn 90 per cent of all of our fuel in that very inefficient way.

If we can put the maximum compression up to, say, 120, 130, or even 140 lb., and not have the engine knock, or break up, we can practically double the efficiency of our engines at car speeds of 20 to 30 m.p.h. It is possible, by cooperation between this organization and the automotive industry, to increase the efficiency of our machines from 33 to 50 per cent.

Why do we not do that? Why can we not do that? When we take a full charge into a cylinder, or when we try to charge that cylinder at the present time, we have two things working against each other. In the first place, we have to add heat to vaporize the fuel; and from the very fact that we have to raise the temperature of the mixture to get vaporization for distribution purposes only, we reach another circumstance. Each fuel gravity carries with it another perfectly positive constant which is a function of two things; the compression to which the charge is subjected, and the temperature upon burning. If we do not pass the critical point for the given fuel, the engine runs very nicely. If we pass the critical point even slightly, the engine does not perform normally; we get a detonation not infrequently equal to the total explosion pressure of the engine, and sometimes very much greater. That is the basic fuel problem in the automotive industry; to keep down detonation.

If we can raise the compression of our engines, we can increase their economy, decrease crankcase oil dilution, improve distribution, and do other things that we cannot do now. We cannot do the things we want to do in the automobile engine until we get the proper fuel work done, and we have difficulty in getting the fuel work done before we get the proper engine. We must carry the movement in coordinated effort of the Petroleum Institute, the automotive industry and the chemical societies. We know enough today in very many ways to improve the present situation.

What we want in the automotive industry is a fuel and a lubricating oil that will give very good efficiency and obviate the necessity of cleaning the carbon out of the engine. I believe that with the right kind of cooperation that can be attained quickly. Carbon deposits contain a mixture that is nothing but a varnish, and acts in exactly the same manner. If that 5 or 10 per cent of binder is dissolved out, the rest of the carbon all goes out, and there is no trouble with carbonization. In other words, anything that is a varnish remover is a carbon remover. That is all there is to it. You can put any kind of a varnish remover in, if it is the right kind.

We have problems and I think we can write them down in a perfectly concrete way. We cannot solve them by some spectacular, skyrocket sort of a plan. We must get acquainted with each other and stop four-flushing. We will tell you what we are, and we think we know what you are.

CIVILIAN AVIATION

T is, indeed, interesting to note the very solid progress that has been made by foreign countries in the promotion of civilian aviation. Undoubtedly, the future will see air lines for passengers, mail and express matter running from Scandinavia to the very tip of South Africa and extending from all parts of Europe to the Orient. Such routes, once established, will save many weeks of time and wearisome travel over present-day modes of land and water locomotion. The fundamental principle behind the success of this infant industry, air transportation, must, of course, be government support. Once established, people throughout the world will accept aerial transportation much after the fashion as they accepted the railroad train despite the pious warnings that it would prove "an instrument of the devil." Today we are beginning to forget the 100 m.p.h. that was attained long ago in the air, and are interested in the fact that 200 m.p.h. has been passed, and that a speed of 500 m.p.h. is not an impossibility.

Major Schroeder proved, in his record-breaking altitude flight that, at about 30,000 ft. trade winds blow from west to east at the rate of 300 m.p.h., which means, at the proper altitude, we could be blown from San Francisco to New York City in 10 hr. Who would venture to say that at 50,000 ft. we might not find a wind blowing from east to west that would carry aircraft in its current at even a greater rate of speed?—Air Service News Letter.

Commercial Motor Boats and the Diesel Engine

By G. C. Davison[1]

Motor Boat Meeting Paper *Illustrated with* Photographs and Charts

THE owner of a commercial motor boat is always interested in the forms of power available for its propulsion. He must have a plant that is not only reliable in operation, but one which is safe, requires a minimum of attendance and is subject to a minimum cost of operation. At the present time the internal-com-

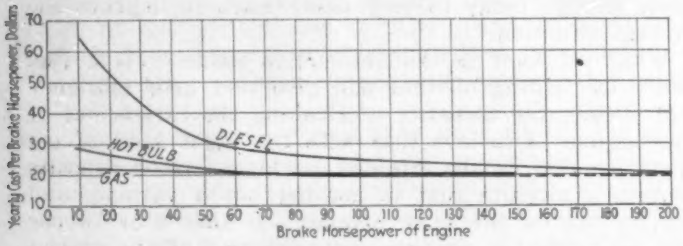


Fig. 1—Chart Showing the Comparative Operating Costs of Diesel, Hot-Bulb and Gas Engines Based upon 250-Hr. Yearly Operation

bustion engine is so far developed that no boat owner thinks of installing anything else in any boat which requires less than several hundred horsepower. In the larger sizes of boat requiring powers of say 300 hp. and over the choice is between steam and internal-combustion engines. Even in this field the steam engine is rapidly being replaced by the internal-combustion engine, so that it can be said that in the commercial motor boat field the boat owner must choose between the various types of internal-combustion engine.

There are, broadly speaking, three forms of internal-combustion engines available today in small and moderate sizes. There is (*a*) the gas engine, (*b*) the surface-ignition or hot-bulb engine, and (*c*) the Diesel engine. There are several variants of these three types, but for the purposes of this discussion only the three general types will be considered. Charts have been prepared which show certain approximate costs of operation of the three types for various sizes of engine. Before discussing these charts in detail, the basis of plotting will be given.

First Cost

These charts cover the fixed charges plus the fuel cost of operation. In establishing the fixed charges it is first necessary, of course, to estimate the cost of installation. This is variable, depending upon circumstances, but as a fair minimum the first cost has been assumed as the cost of the engine plus 15 per cent. This 15 per cent represents the cost of installing the engine in the boat complete with all piping, shafting, propellers and such auxiliaries as are necessary for the operation of the ship. In case the machinery is to be installed in an old boat, this item will be greatly increased, but the relative proportions will scarcely be changed. The first cost of the engines only has been estimated as follows:

FIRST COST OF VARIOUS ENGINES

Type and Size of Engine	Cost per b.hp.
25-hp. Diesel	$200
25-hp. Hot Bulb	100
25-hp. Gas	60
50-hp. Diesel	125
50-hp. Hot Bulb	85
50-hp. Gas	60
100-hp. and larger Diesel	100
100-hp. Hot Bulb	75
100-hp. Gas	60

In considering these costs, it must be remembered that these remarks apply only to heavy-duty engines suitable for work boats. If light weight high-speed engines are concerned the proportions will be entirely changed. The total fixed charges for each year have been taken at 20 per cent in each case. This 20 per cent consists of 11 per cent for depreciation, 6 per cent for interest on the investment and 3 per cent for repairs. The depreciation item is perhaps rather severe on the Diesel engine, but for the purposes of this comparison it was thought better to assume the same percentage in all cases. For the 100-hp. sizes the fuel consumption has been taken as 6½ gal. per hr. for the Diesel, 9 gal. per hr. for the hot-bulb engine and 10 gal. per hr. for the gas engine. The fuel consumption has been increased somewhat for the smaller sizes and decreased slightly for the larger sizes It varies with the mechanical condition of the engines and the care of the operator much more in the case of the gas engine than in the hot-bulb, and the hot-bulb is more sensitive than the Diesel, but these consumptions have been taken as representing good average conditions with care upon the part of the operator. A poorer consumption on the part of the other engines will only make the case more favorable for the Diesel engine. The prices of fuel have been assumed as 10 cents per gal. for the Diesel and hot-bulb engines, and 26 cents per gal, for gasoline for the gas engine. These are less than the present day retail prices along this section of the Atlantic coast, but the price ratio will remain about the same in any case and the shape and relative positions of the curves will not be changed.

Fig. 1 is a chart representing 250 hr. of operation per annum, which is about the average for a yacht, Fig. 2

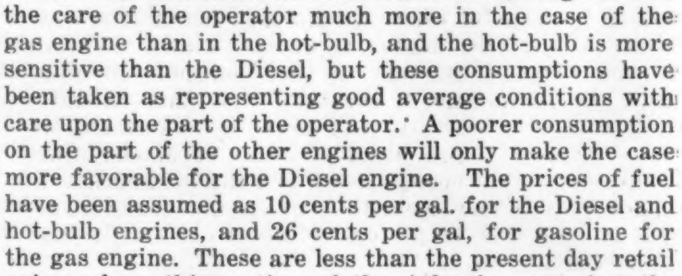


Fig. 2—Chart Showing the Operating Cost for Various Types of Internal-Combustion Engines Based on an Annual Operating Time of 1500 Hr.

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represen s 1500 hr. of operation per annum, which is about the average for a work boat in a seasonal trade, and Fig. 3 is for 3000 hr. of operation per annum, which covers approximately the case of the boat which is used the year round. An inspection of these charts will show at a glance that the gas engine is out of the running entirely except in the case of the yacht; that is to say, in spite of its low first cost, the high cost of fuel brings up the cost of operation so that within the limits of sizes under discussion it is almost never economical to install a gas engine. The boat owner simply cannot afford to install a gas engine in any size where the oil engine is available.

There is another very important item in this connection which is not shown in the charts but should be brought out at this time, and that is the question of insurance. Most of these small commercial work boats are of wooden construction, and the insurance rates are high enough in any case, but with a gas engine and the presence of gasoline in large quantities with the attendant danger of fire, the insurance companies demand a higher rate of insurance than they do in the case of the oil-engined vessel. This omits, of course, the question of safety of the crew, but in a seagoing vessel this must not be ignored, and makes the case all the stronger for the oil engine. Both the hot-bulb and Diesel types of engine use a fuel of high enough flash point so that there is practically no danger of fire due to the presence of the fuel itself even with the most ordinary precautions. The hot-bulb engine has a slightly increased fire risk as com-

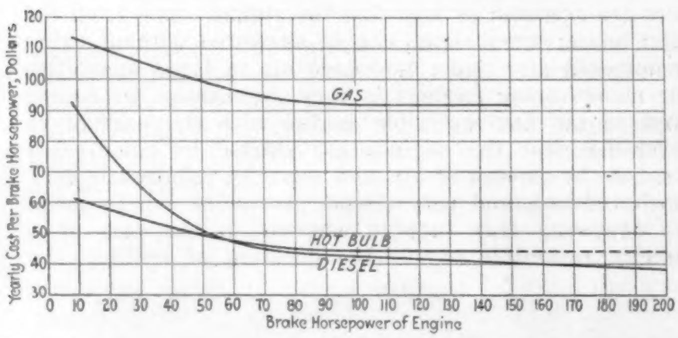

Fig. 3—Operating Cost of an Engine in a Vessel Which Is in Service for 3000 Hr. Annually or Practically the Entire Year

pared with the Diesel engine on account of the use of open flames for heating the bulbs when preparing for a start, but this is not a serious risk even for these engines, and in some forms of hot-bulb engine, and all types of the Diesel engine, this is eliminated entirely. The question, then, comes down to a choice of a Diesel or hot-bulb engine.

Fuel and Lubricant Economy

The charts show that for 250 hr. or less yearly operation the Diesel engine cannot overcome the handicap of a large initial first cost with its superior fuel economy; for 1500-hr. operation per year there is very little to choose for 100-hp. sizes and over, but as the number of hours of operation increases to 3000 the superior oil economy of the Diesel engine asserts itself and the Diesel engine has a decided advantage.

The curves do not show all of the advantages of the Diesel engine. As a matter of fact, the Diesel engine can use a wider variety of fuel than the hot-bulb engine, and more important, can use fuels of a heavier grade. With the present fuel situation, this is a factor that must not be overlooked because the present fuel outlook indi-

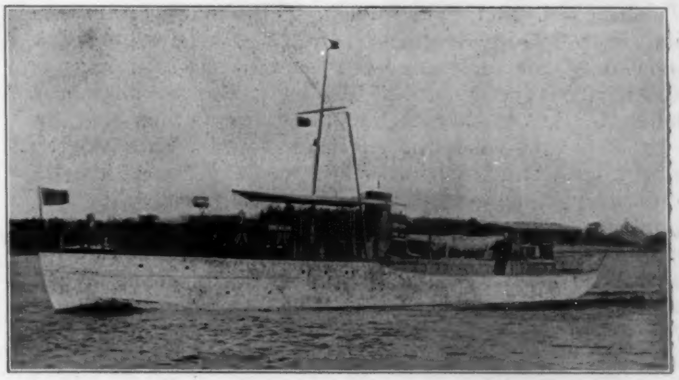

Fig. 4—A Yacht Equipped with a 120-Hp. Diesel Engine

cates that heavier grades of fuel will be more readily available in the future than the lighter grades, and with a Diesel engine installed the boat owner need not worry about the future in this respect; while with the hot-bulb engine there seems to be a possibility that in the future there may be such a scarcity of the lighter grades of fuel oil as to force the price upward. Another important point is the mechanical operation of the two types of engine in the various sizes. In sizes up to, roughly, 100 hp., the hot-bulb engine is reported in a great many cases to have given eminent satisfaction as regards operation, but there are several cases on record in the larger sizes where the owners have had many difficulties. On the other hand, the Diesel engine while functioning perfectly in the small sizes is very expensive to build relatively, and does not show a marked superiority in cost of operation over the hot-bulb engine. When it comes to sizes of 100 hp. and over, the superior mechanical performance of the Diesel engine and its advantage in cost of operation becomes more marked, and the larger the size of the engine the more advantage the Diesel engine has in these two respects. Along this line it is to be noted that certain makes of hot-bulb engine have added a small air compressor and changed the cycle of operation to more nearly that of a Diesel engine in the larger sizes.

The consumption of lubricating oil has not been figured into these curves, and it has been taken as the same for all of the types of engine of a given size. This is approximately true in considering the best types of hot-bulb engines working under the best of conditions, but since most engines of this type have crankcase compression and port scavenging of the working cylinder, the consumption of lubricating oil is likely to be very high unless the design of the engine provides for this contingency with special mechanical features which prevent undue leakage of oil from the bearings into the crankcase, and even with these added features they must be kept in the best mechanical condition. This means that the Diesel engine has as good a lubricating oil consumption as the hot-bulb engines under the best conditions, and under the worst conditions the Diesel engine has a decided advantage. In this connection it can be stated that a fair lubricating oil consumption for a Diesel engine is from one-fiftieth to one-seventy-fifth of the fuel oil consumption at full power.

The question of attendance is another item that has not been included, but this is more or less a constant for all sizes and types of engine under consideration. In boats of this type it is customary to carry only one engineer except in the case of large powers where the operation involves 24 hr. per day running. In the case

of fishing schooners which have 100-hp. and even in some that have 180-hp. engines installed it is customary to carry only one engineer even though non-stop runs of 80 hr. are very common. Under these circumstances the engine has to take care of itself for periods of 4 and 5 hr. at a time while the engineer sleeps. This practice is, of course, not to be recommended, but these are the actual conditions obtaining, and show the reliability and simplicity of powerplants of this type. In the case of small harbor boats, it is customary to have the engines controlled from the pilot house, and oftentimes in this case the entire crew consists of a captain and deckhand. Where 200 hp. or more is installed, and particularly in the case of vessels depending upon their engine power alone for propulsion, several engineers are carried; but in any case the number of men carried and the cost of operation depend upon the size of the powerplant and conditions of operation rather than upon the type.

No marine powerplant can be considered which is not reliable. In fact, several other shortcomings can be tolerated but unreliability cannot. The question of fire risk has already been discussed and the advantage of the oil engine shown. As for mechanical operation there is little choice as with a properly designed and installed engine, any one of the three types under discussion is thoroughly reliable as is daily attested by the large number of boats in operation which depend entirely upon these engines for their propulsion.

Mechanical Reversing Gears

It has been shown that the Diesel engine has a field almost to itself in sizes above 100 hp., and even today as young as the industry is the type of engine most suitable for this class of work has been very thoroughly proved. It will be found that the Diesel engine almost universally used in these sizes is of the four-cycle type. This is because of the greater simplicity as compared with the two-cycle type. In this size of four-cycle it is not necessary to cool the working pistons; hence all complications inside of the crankcase are omitted. Also a mechanical reversing gear is cheaper and has many operating advantages over a directly reversible engine. This means that the number of cylinders and mechanical arrangement on the engine are not primarily dependent upon the requirements for reversibility, but can be chosen to best suit other conditions. Therefore it is found that the usual type is a four or six-cylinder, four-cycle engine made reversible by the use of a mechanical gear. The four-cycle engine is also slightly more economical as regards fuel consumption than the two-cycle, and there are certain other mechanical advantages, such as reversing of pressure on the bearings and easier heat conditions in the working cylinders which make the four-cycle look so attractive.

The question of where to begin to build directly reversible engines and leave off the mechanical reversing gears is one that depends upon many factors. With a directly reversible engine a minimum of six cylinders is required to provide for reversibility under all positions of the crank; whereas if a mechanical reversing gear is fitted, a four-cylinder engine can be used which will provide larger cylinders and a lower number of revolutions per minute for a given horsepower. This is an advantage in marine work as it provides a more efficient propulsion with a reduced number of revolutions, and this is advantageous from the mechanical standpoint where hard continuous service is expected over long periods. The weight and cost is, of course, slightly increased as compared with a six-cylinder engine; but the other advantages outweigh this disadvantage. If considerable maneuvering is to be done, the mechanical reversing gear has a decided advantage, because no matter how many maneuvers are executed or how fast the signals come from the pilot house, every signal can be answered without using compressed air; and compressed air in large quantities for maneuvering engines is very expensive. Of course even on the non-reversible engine with the mechanical reversing gear the engines are started by compressed air, but the amount of air-flask capacity required is very much reduced, and very simple provisions can be made for renewing this supply; whereas in the case of a directly reversible engine the question of refilling the

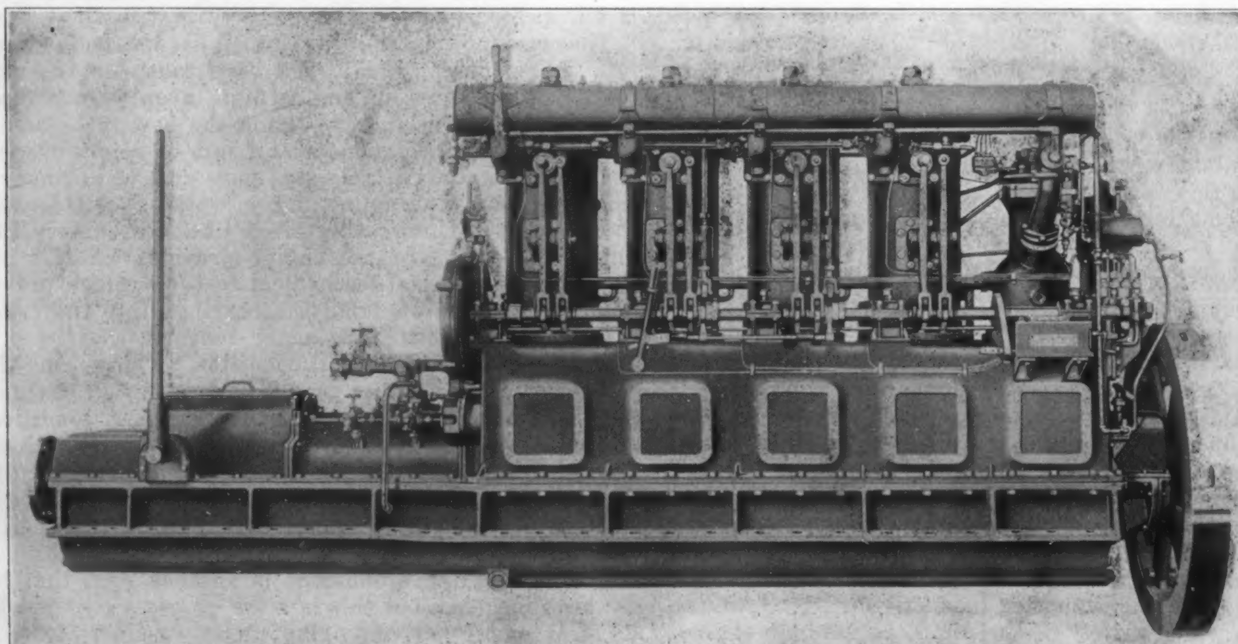

Fig. 5—A Four-Cycle Four-Cylinder Diesel Marine Engine Developing 120 B. Hp. at 350 R.P.M. Which Is Equipped with a Reversing Clutch and Thrust Bearing Fitted on an Extension of the Bedplate

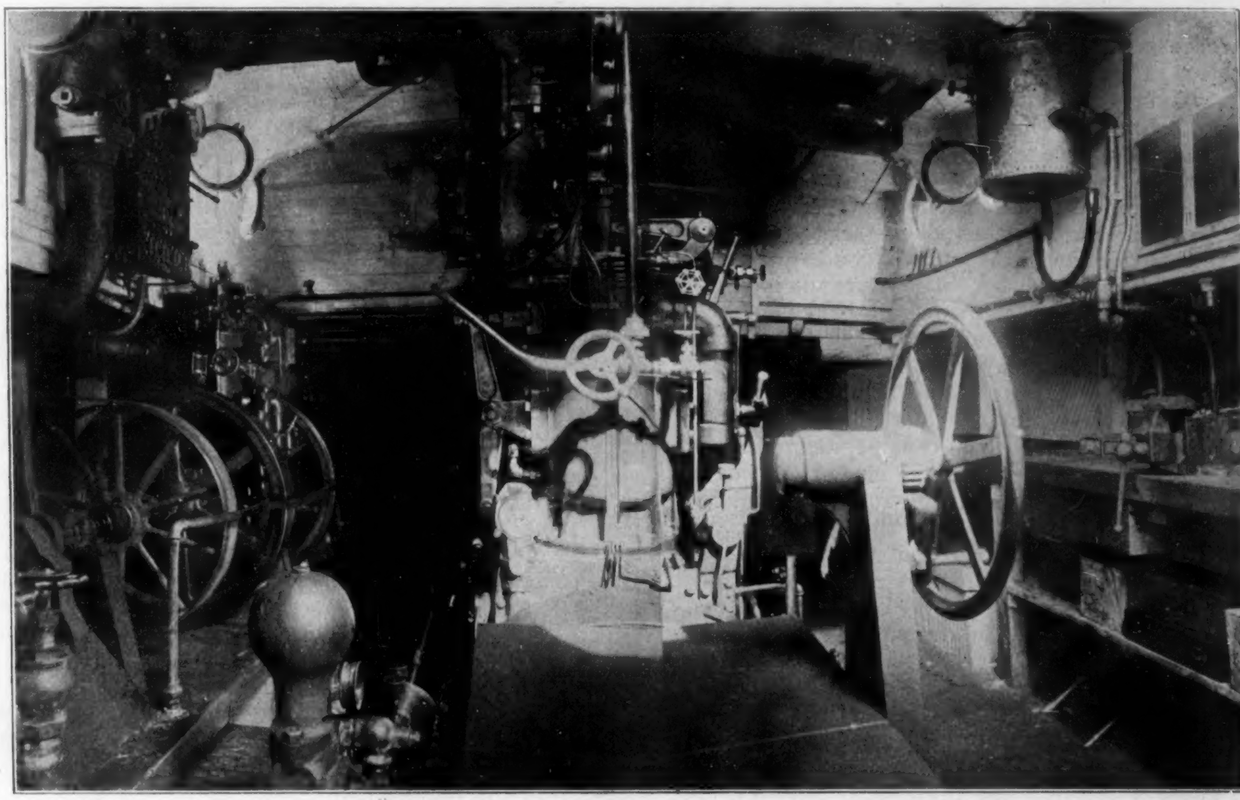

FIG. 6—THE ENGINE ROOM OF A CANNERY TENDER EQUIPPED WITH A DIESEL ENGINE

starting flasks is an important one, and in some cases would require the supplying of a separate auxiliary compressor unit for this purpose alone. When it is considered that in the case of tug boats and some fishing vessels that 5 or 6 hr. continuous maneuvering with a signal from the pilot house every few minutes or oftener is the condition to be met, the advantages of a non-reversible engine with a mechanical reversing clutch are evident. The question of obtaining a reliable mechanical reversing clutch is very important. There are many gears on the market for the smaller sizes say up to 100 hp., but in powers larger than this there are very few firms in a position to supply a clutch powerful enough to withstand the severe usage given it under the circumstances just mentioned, and in many cases the engine builder is driven to designing and building his own clutch especially for his engine. The point is soon reached in size, however, where the mechanical reversing clutch becomes extremely large, heavy and costly, and then in spite of its advantages from the operating standpoint, it is necessary to get back to a directly reversible engine. There is, of course, no definite line of demarcation, but it is considered that somewhere in the vicinity of 300 hp. it is generally cheaper to build a directly reversible engine than it is to build a mechanical reversing clutch which will be stout enough to stand up with the engine.

THE ELECTRIC DRIVE AND THE STEAM ENGINE

There is another solution to the problem of reversing the propeller in a motor boat and that is the electric drive. In this case a non-reversible engine or engines drive generators and run at a constant speed. On the propeller there is a motor which receives its power from the generators and its speed and direction of rotation are controlled by electrical means. This type of installation has several advantages, particularly for some special cases like fishing trawlers, tug boats and fire boats. In the first place it is usual to provide at least two engines even for a single-screw boat. This gives added reliability, reduces the first cost because smaller engines are used than in the case where one engine alone is used, there is extreme flexibility and the controlling of the boat from the pilot house is a very simple matter. A very important feature, however, is that in case the boat is slowed down the motor only takes the overload and the engines and generators run at regular power and speed. This particular phase is important for tug boats and fishing trawlers where for a very large portion of the time the speed of the boat is slowed down due to resistance of the tow or of the trawl, but full power is desired from the propelling machinery. In the case of direct-connected engines under these circumstances the revolutions of the propeller are, of course, decreased, which in turn decreases the power

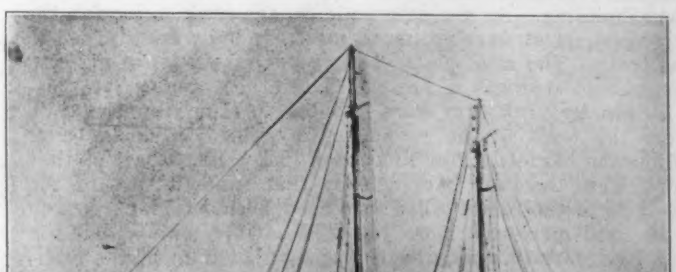

FIG. 7—A TYPICAL EXAMPLE OF A FISHING SCHOONER DRIVEN BY A DIESEL ENGINE

output available from the engines. The advantage in the case of a fire boat is in the great flexibility of control and operation; that is the engine would drive the generators at constant speed and power could be taken as required for the motors, for propulsion and the motor-driven fire pumps.

As has already been mentioned, the Diesel engine in the larger sizes of several hundred horsepower for commercial work boats has for its principal competitor the steam engine. One particular phase of this competition is in the case of the fishing trawler. These vessels have long runs from their home ports to the fishing banks and hence require considerable amounts of fuel to take them to the fishing banks and back, to say nothing of that consumed while trawling on the banks. These boats are of course only of moderate sizes and the question of radius of action is very important. In the case of steam trawlers it actually requires an increase in the size of the boat in order to be able to carry coal enough for the round trip, and even then some of the banks in the North Atlantic which are fished from New England ports are so far away that the steam trawlers cannot carry fuel enough to make the trip. In the case of the Diesel engine matters are entirely different. The company which I represent has made two installations in boats of this character. Both of them are about 150 ft. long and carry approximately 300,000 lb. of fish. One boat has a 360-hp. directly reversible engine and the other has two 240-hp. engines with the electric drive. A speed of approximately 10 knots is obtained and these boats have a cruising radius at full speed of about 6000 nautical miles and at three-quarters speed of about 9000 nautical miles. This is more than sufficient to take them to the farthermost fishing banks and back. In other words, in this particular field the Diesel engine has no competitor and while these faraway banks are not fished very much at present on account of the plentiful supply of fish nearer home, yet it may mean in the future that all trawlers with the exception of those propelled by Diesel engines will be driven out of the business.

In conclusion then it can be said that for yachts or for any boat which operates very little, the first cost is of more importance than the cost of fuel and hence the gas engine has a decided economical advantage. This advantage is more and more pronounced as the size of the powerplant is decreased. But in the vast majority of cases, some form of oil engine is the only type which a commercial motor boat owner can consider which will meet all of his requirements. For sizes of 100 b.hp. and less, some form of hot-bulb or surface-ignition engine has the field to itself, but for sizes above 100 hp. the Diesel engine shows its superiority more and more until for 200 or 300 hp. and more, it, in turn, has the field almost entirely to itself. The ordinary tug boat, passenger boat and fishing boat uses the Diesel engine because of its economy, and the fire boat will use the Diesel engine because of its absence of standby losses. Reliability, simplicity and ease of attendance are essential in all cases, and the present day Diesel engine is fully up to the requirements.

TANK CARS

TANK cars of one kind and another have been used for about 50 years. In the beginning they were really "tub cars," a wooden vat or set of vats on a flat car. As the petroleum industry began to grow it was soon found that shipping the crude oil in barrels was too slow and costly and various designs of tank cars were invented. In general, however, the practice was to build a cylinder, strap it down on a flat car, locking it in place by blocks and braces. There was virtually no standard of any kind, no rules of construction to be observed, until 1903; if the running gear passed inspection it was presumed the car was alright. In 1903 the Master Car Builders' Association adopted rules to be followed in building tank cars, which rules continued with no important changes until 1916. In that period the growth of the use of tank cars increased enormously and it became necessary to prescribe rigid requirements to be followed in their building. As we now build it, the tank is by far the strongest, most durable, most carefully built freight car in the train. The steel plates must be of steam-boiler quality; exceptional strength is prescribed for the frame.

Originally tank cars were adopted for carrying crude oil from the wells to the refinery, the refined products being shipped in barrels. Pipe lines soon took a large part of that work from the tank cars, but by that time the use of the products of the refinery had increased so that tank cars came to be used more and more for these. Of recent years tank cars have carried chiefly loads from, rather than to, the refineries. But as the search for production goes on and new and temporary fields are brought into production, the tank car takes up again its original function and handles the crude oil from the fields not yet developed to the point where pipe lines would pay. There are many such fields now and with the constant demand for more oil and the consequent widening of the search for production this use of tank cars must increase.

It is roughly estimated that there are about 130,000 tank cars in the petroleum service in the country today, worth about $300,000,000. Hundreds of commodities formerly shipped only in carboys, drums or barrels now use long lines of tank cars. There is no such thing really as a general service tank car. For each commodity the car must be carefully adapted and designed. Loading and unloading devices, heater coils and special features of many kinds distinguish a car for one service.

The insulated tank car came into being first to meet the need for a car to handle the highly volatile casinghead gasoline. Its proved economy in operation, reducing evaporation losses to a small fraction of that occurring to shipments in plain tank cars, is causing it to be adopted for straight-run gasoline as well. Probably one of the largest single items of gasoline waste is the evaporation in transit in plain tank cars. Even in the most carefully built modern but non-insulated tank car, with a dome cover and the safety-valve fitting tight and accurately, the loss by insensible evaporation on a six-day trip in summer may run from 5 to 6 per cent or more. That means 400 to 500 gal. per car per trip.—Max Epstein at a recent meeting of the American Petroleum Institute.

THE PHOTOGRAPHIC RECORDING OF SMALL MOTIONS

THE problem of recording small and perhaps rapid motions often comes up in research work and instrument design and the pen and lever are frequently used where an optical method would be far superior. The latter is not used more probably because very little definite information is available on its design and possibilities. For this reason the National Advisory Committee for Aeronautics, Washington, has issued Technical Note No. 22 dealing with this subject. This report has been prepared by F. H. Norton, physicist in the Committee's aerodynamical laboratory, and is based upon data obtained as the result of a large number of tests made at the field station.

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Petroleum Refining Processes and Problems[1]

By H. H. Hill[2]

THE problems encountered in the refining of petroleum differ greatly with different crudes and with different types of plants. The difficulties encountered in the manufacture of lubricating oils from California crude are, for example, of an entirely different nature from those encountered in the manufacture of lubricating oils from Pennsylvania crude; in the first case the chief problem is the removal of large percentages of asphaltic material, and in the second the separation of paraffin wax. The problems of each plant are more or less governed by the products that it manufactures.

Depending upon the class of products manufactured, the refineries in the country can be grouped under the four general heads of topping plants, skimming plants,[3] complete refineries and refineries with cracking plants.

In California and in Mexico certain of the heavy crudes are used directly as fuel oil, while others contain small amounts of comparatively light fractions that must be removed to obtain fuel oils with satisfactory flashpoints. For the purpose of removing these lighter fractions, topping plants are generally employed. In this type of plant the oil is sometimes heated in conventional horizontal crude stills, but in most cases the stills are made up of coils of pipe through which the oil is passed continuously. The chief product of such plants is fuel oil, although the distillate or tops contain varying amounts of either gasoline, naphtha or kerosene, depending upon the crude oil used. This distillate is sometimes refined at the plant and used for blending with casinghead gasoline, but is frequently sold to other refineries. Topping plants are in many cases operated by producing or pipe-line companies for the purpose of dehydrating the oil or removing the lighter fractions prior to sending the oil to storage for long periods of time.

A type of plant that is very common throughout the Mid-Continent region is the skimming plant. Plants of this nature remove only the lighter fractions from crude petroleum, not being concerned with the manufacture of products from the heavy residues. They are generally adjacent to producing fields and, since gasoline is their most important product, are usually located in districts where crudes of high gasoline-content can be obtained. In many cases they are changed into complete refineries for by the addition of rerun stills and equipment for the removal of wax and for treating and filtering the heavier distillates, plants of this nature can be converted into refineries capable of manufacturing lubricating oils. Skimming plants produce gasoline, naphtha, kerosene, gas oil and fuel oil.

Refineries that manufacture lubricating oils in addition to the products turned out by skimming plants are generally referred to as "complete refineries." Practically all the large plants in the country and a number of the small refineries, particularly those in Pennsylvania, belong to this class. They are in most cases located at the terminals of trunk pipe-lines or operated by companies that control production and are thus assured supplies of crude for a comparatively long period. The problems encountered by plants of this type relate to the production and refining of a wide range of petroleum derivatives including lubricating oils and paraffin wax in addition to light oils handled by skimming plants.

Plants in which gasoline is produced by decomposing heavy fractions such as gas oil and fuel oil, under heat and pressure, are known as cracking plants. In a few cases plants of this nature are operated in connection with skimming plants but chiefly as adjuncts to complete refineries.

Gasoline Quantity and Quality

In the case of gasoline the chief problem at present is that of increased production. The quality, although important, is more or less controlled by supply and demand. The three methods for increasing production that appear to offer the greatest possibilities are the lowering of the volatility, increased efficiency in refinery operations and a more universal use of the cracking process. Increased yields of gasoline have been obtained to a large extent by cutting more deeply into the crude and including in the gasoline cut certain fractions that were formerly included in kerosene. This has resulted in gasolines of lower volatility, or in other words higher end-points. Only a few years ago the average end-point of engine gasoline was below 400 deg. fahr. A recent survey made by the Bureau of Mines has shown that the average end-point of products now marketed in seven large cities in different sections of the country is 456 deg. fahr. It is a question how much higher the end-point can be raised before the product will become unsatisfactory for use in the present type of automobile engine. One thing is evident, however; if the end-point of gasoline is raised much above the present figure, it will be necessary for the refiners to increase the percentage of highly volatile fractions, which at present is being accomplished by adding casinghead gasoline. The refiner who desires to increase the yield of gasoline by cutting more deeply into the crude is confronted with the problem of obtaining supplies of casinghead gasoline.

The yield of gasoline can be appreciably increased by improvements in refinery operations. As approximately 80 per cent of the gasoline produced is obtained by straight distillation of crude oil, an increased efficiency of only a few per cent would add millions of gallons to the gasoline supply. One method of increasing the efficiency of gasoline recovery is by the use of dephlegmators or fractionating towers. Most of the large refineries use fractionating towers on both crude stills and steam stills and as a result are able to obtain the maximum yield of gasoline from the crude without impairing the

[1]From an address delivered at the convention of the Independent Oil Men's Association, Denver, Col., Sept. 30, 1920.

[2]Chemical engineer, Bureau of Mines, Washington.

[3]The terms "topping plant" and "skimming plant" are sometimes used interchangeably, the former being in accord with California and the latter with Mid-Continent usage. There is, however, a real distinction between typical plants of each class, both from the standpoint of plant equipment and in the relative importance of the products. In this paper the term "topping plant" refers to the type of plant employed primarily for the production of fuel oil, and the term "skimming plant" to operation for the production of gasoline and other light distillates, fuel oil being considered as a secondary product.

quality of the product. A large number of the small refineries do not make use of any fractionating equipment and, to obtain gasolines with satisfactory end-points, the cut for gasoline is frequently made before all fractions that could be included with gasoline have distilled off. It is believed that a general use of efficient fractionating towers would allow refiners to obtain considerably larger amounts of gasoline without increasing the consumption of crude or raising the end-point of the product.

Another means for increasing the yield of gasoline is by recovering it from the uncondensed still vapors. An appreciable amount of gasoline is not condensed when the vapors from the stills are passed through an ordinary condenser. A few refineries have installed compressors or absorbers for recovering this uncondensed gasoline and in some cases report yields as high as 2 per cent of the crude distilled or approximately 6 per cent of the total gasoline production of the plant. A large percentage of the refineries, however, have not made provisions for recovering gasoline by this method, but continue to burn this valuable gasoline fraction under their stills and boilers.

Cracking Processes

The quantity of gasoline that can be produced from a given amount of crude could be increased by a more general use of the cracking process. The Burton process, since it was first installed on a commercial scale, has produced approximately 40,000,000 bbl. of gasoline from heavy distillates and has thus saved approximately 150,000,000 bbl. of crude that would have been necessary to produce an equivalent amount of gasoline. A number of other cracking processes have been patented and a few are operating on a commercial scale, but those now in operation, including the Burton process, are using distillate oils or comparatively light residuums as crude materials. One of the most important problems in the refining of petroleum is that of producing gasoline from heavy residuums and a cracking process that could handle such oils satisfactorily would almost revolutionize the refining industry. The heavy oils of California, Mexico and the Gulf Coast, and the residual fuel oils now marketed by Mid-Continent refineries, could be made to yield enormous quantities of gasoline if a method were developed by which they could be economically utilized for gasoline production. Probably no refining problem has been the source of so much laboratory and experimental work as the production of gasoline from heavy residual oils, and although small-scale operations have been encouraging in many cases, comparatively little gasoline is now made from oils of that character.

Kerosene

For the present at least, the problem of increased production of kerosene is not of major importance. In 1919, due to the large quantities that were exported to countries that had obtained limited supplies during the war, there was a decided demand for kerosene and stocks were depleted somewhat. During 1920, stocks have been accumulating and there has been a considerable change in the export market. Although the refiners are evidently experiencing little difficulty in meeting the present demand for kerosene, the kerosenes of today are somewhat heavier products than those marketed a few years ago and are somewhat more difficult to treat for both odor and color. There is also the problem of manufacturing products of the proper viscosity to give satisfactory service in the ordinary wick burners. Due to the fact that increasing amounts of the lighter kerosene-fractions are being included in the gasoline cut, it may become necessary to either divert certain of the heavier fractions to gas oil to produce kerosenes of satisfactory viscosity, or slightly modify the present types of burners to permit the utilization of heavier products.

Lubricating Oils

The production of lubricating oils has always given the refiners more or less trouble, due largely to the fact that the various processes must be very carefully controlled to insure uniform products. There are crudes, found in very limited quantities, that are used as lubricants after having been reduced and filtered. Others, such as Pennsylvania crude, that contain very small percentages of asphalt, can be converted to lubricating oils by removing part of the wax, reducing and filtering. Other crudes, such as those obtained from the Mid-Continent, California and Gulf Coast fields, must be subjected to special treatment to produce lubricating oils free from asphaltic material.

Although the demand for lubricating oils has been increasing, there are no apparent possibilities of a shortage except in the case of special products. There is, however, a scarcity of the grade of lubricating oils known as cylinder stocks. These oils are residual products in the distillation of petroleum, are of high viscosity, have high flash and fire-points and are used for lubricating the cylinders of steam and gas engines. They are used also for blending with other stocks for the manufacture of automobile engine oils. The straight paraffin-base oils, such as are the grade known as Pennsylvania crude, are particularly suitable for the manufacture of cylinder stocks, as it is not necessary to treat the reduced crude with acid to remove asphaltic material.

Some of the Mid-Continent crudes make satisfactory cylinder stocks, but it is necessary to subject the crude to a chemical treatment before it is reduced to stock. This of course increases the cost and unless the process is very carefully controlled, the product is not always satisfactory. Although cylinder stocks are now made from some of the Mid-Continent crudes, and others tested have given encouraging results, nevertheless one of the chief problems before the refiner today is the manufacture of cylinder stocks from crudes other than those produced in the Appalachian field.

There are numerous other problems in the production of lubricating oils that are of prime importance to the refiner. Conditions for treating and filtering differ entirely with different crudes. Experimental work should be done to determine the best methods for handling each type of crude. The color of lubricating oils is a property that should be carefully studied to determine its importance as a means of judging quality. The problem of obtaining uniform products is one of utmost importance, with reference particularly to such properties as flash, viscosity and cold test.

Gas Oil

During the past year artificial-gas plants have been encountering considerable difficulty in obtaining supplies of gas oil. This product until recently was comparatively cheap and could always be obtained in adequate quantities. The increased use of artificial gas has been largely responsible for the shortage, although the high price of fuel oil has doubtless reduced the production of gas oil to a certain extent. Another possible reason for the shortage is the increasing quantities that have been used in the production of gasoline by cracking processes; the amount used for this purpose has practically doubled during the past three years.

The problem of increased production of gas oil is purely an economic one, for adequate quantities can be obtained provided the difference in price between gas oil and fuel oil is sufficient to warrant the increased cost of production. It is questionable, however, whether it would not be advisable for the gas companies to make use of the lighter residual fuel oils, in that way reducing the cost of their raw material and at the same time permitting the utilization of gas oil for other purposes such as the production of gasoline by employing some one of the various cracking processes.

Increased production of fuel oil cannot be obtained except at the expense of other products that are more valuable, namely, gasoline, gas oil and lubricating oils. It is believed, however, that the fuel oil now produced can be sacrificed to better advantage than the production of other petroleum products.

At present, the problems of considerable importance in connection with the production of fuel oil are the methods of reducing the sulphur content of oils that are exceptionally high in sulphur and means for reducing the viscosity of the heavier fuel oils.

HIGHWAY TRAFFIC REGULATIONS

THE associations represented at the organization meeting of the National Conference on Highway Traffic Regulations at Cleveland last month and invited to take part in the meeting to be held at Washington this month, were, in addition to the Society

American Automobile Association
National Automobile Chamber of Commerce
National Automobile Dealers' Association
Rubber Association of America
Trailer Manufacturers' Association of America
Motor and Accessory Manufacturers' Association
American Electric Railway Association
American Railway Association
Automobile Club of Southern California
Cleveland Automobile Club
Illuminating Engineering Society
National Association of Brotherhoods of Threshermen
National Implement and Vehicle Association
National Safety Council
National Workmen's Compensation Service Bureau
Ohio State Automobile Association
Underwriters' Laboratories
Wagon Manufacturers
American Society for Municipal Improvements
International Association of Chiefs of Police
American Association of State Highway Officials
National Automotive Equipment Association
Interstate Commerce Commission
National Highway Protective Society
Council of National Defense
Department of Agriculture
National Automotive Underwriters' Conference
National Association of Mutual Casualty Companies
International Traffic Officers' Association
National Grange
National Farm Bureaus Federation
National Team and Truck Owners' Association
Chamber of Commerce of United States
National Highway Engineers' Association
Association of Secretaries of State
Governors' Conference
National Committee on Uniform Laws
Federal Highway Council
National Thresher and Tractor Association
National Furniture Warehousemen's Association
California State Automobile Association
State Automobile Association of Indiana
State Automobile Association of Illinois
State Automobile Association of Pennsylvania
State Automobile Association of New York

The legislatures of 42 States will begin their biennial sessions this month and unless a standard vehicle law can be agreed upon, the possibility of bringing about legislative uniformity will be delayed at least two years. The necessity for the standardization of vehicle laws is becoming imperative. It is estimated that there are in the cities of the United States approximately 1,000,000 arrests for traffic law violations each year, and records indicate that a very large proportion of the fatalities and injuries caused by automobile accidents results from the violation and ignorance of traffic laws. It is expected that a traffic law adopted by the majority of the States would

(1) Reduce the number of automobile accidents
(2) Relieve municipal courts now flooded with traffic violation cases
(3) Obviate much property damage
(4) Speed up traffic in the congested districts of cities by making it possible for the motorist to know what to do and expect from other motorists

AIRPLANE STRESS ANALYSIS

A HANDBOOK of airplane stress analysis has been published, as Report No. 82, by the National Advisory Committee for Aeronautics. It was prepared in 1917, for the Chief Constructor of the Navy, Admiral D. W. Taylor, and was primarily intended to aid those who had to make estimates of airplane stresses and factors of safety for the Government.

The text, written by Dr. A. F. Zahm, comprises three parts. Part I, being introductory, presents briefly the mechanics of materials and of elementary structural members, Part II treats of airplane wing stresses and Part III treats of body stresses. Part IV, written by L. H. Crook, gives in detail the numerical solutions of the illustrative practical problems presented in the text by the use of the methods and equations therein formulated. Finally in Part V, prepared by the authors jointly, are assembled the tables, formulas and descriptive diagrams illustrating the text; also the graphical solutions of many of the standard stress problems given in the text, and previously solved numerically in Part IV.

The whole work, comprising 70 pages, is compact and orderly, with only brief arguments or explanations, and assumes that the reader has had an average engineer's training in the mechanics of materials and elementary structures. It is a handbook and not a treatise. A copy of this report can be obtained from the National Advisory Committee for Aeronautics, Washington, upon request.

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A New Principle of Engine Suspension

By S. E. Slocum[1]

Illustrated with Drawing

Among new developments in the automotive field, there is none which offers greater possibilities than the redesign of the engine suspension to eliminate vibration. The question of overcoming vibration is closely related to the fuel problem, for vibration is responsible for a much greater loss of power and a consequent increase in fuel consumption than ordinarily is supposed. The common impression seems to be that, while vibration is undesirable, it absorbs but a small amount of power. This is not substantiated by actual facts. Two instances are given to show what large power losses may result from vibration in certain cases. The first is that of an automobile engine which had a badly balanced crankshaft. In a road test it was found that the limiting speed for this car was about 20 m.p.h. and that it was impossible to climb a certain hill in high gear. After the crankshaft had been balanced, no other part of the engine having been touched, the limiting speed of the car was found to be doubled and the hill that previously could only be climbed in intermediate gear could now be taken easily in high.

The second instance is an experiment made by Professor Sommerfeld in 1902, and published in *Zeitschrift des Vereins Deutscher Ingenieure*, page 391, in which he clearly demonstrated the loss of power due to vibration, also determining the actual percentage of loss that may occur in extreme cases. In this experiment an electric motor was mounted on a wooden table, the idea being to reproduce the condition of a machine mounted on the upper floor of an ordinary building. When the speed of the motor was 310 r.p.m. the table began to vibrate excessively. When this vibration of the table was artificially checked, the motor instantly increased its speed, and when the table was again released, it no longer vibrated. The speed of the motor was therefore limited by the vibration of its support. When the speed of the motor was doubled, the centrifugal force, of course, was increased four-fold, and yet the table suddenly ceased to vibrate, the reason again being that the critical speed had been passed. The speed of 310 r.p.m. at which the table began to vibrate excessively was attained with a power supply of 10 watts. An increase in the power supplied merely increased this vibration without increasing the speed of the motor. In fact the speed remained practically constant at 310 r.p.m., until the power supply rose to 30 watts. In this case, therefore, two-thirds of the power supplied at this speed was absorbed in the vibration of the support. These experiments indicate not only how much power can be absorbed by vibration, but also that this power loss may be due to supporting a machine on a badly designed foundation. That is, at certain speeds, the support itself if improperly designed may absorb a considerable percentage of the indicated power.

In addition to power losses, excessive vibration has other disastrous effects. The continued reversal of stress in a vibrating body produces fatigue of the material and ultimately results in the failure of the part. This is a fact of common occurrence in all types of machinery. In the case of large machines mounted on heavy concrete foundations, such as turbo-generators, vibration results in disintegration of the concrete, allowing the machine to settle out of alignment. In electrical machinery, vibration causes poor commutation, often to such an extent as to result in serious electrical losses. These are a few instances of the waste of energy in vibration. and its destructive effects.

Critical Speeds

The most serious losses due to vibration occur, of course, at the so-called critical speed. There seems to be considerable misunderstanding as to just what is meant by critical speed. What it amounts to is that every elastic body, if displaced from its position of equilibrium and then released, will oscillate about this position with a certain definite frequency or period. This oscillation, or vibration, dies out more or less quickly, depending upon the molecular and other resistances. Such oscillations which a body performs of itself are called natural or free oscillations, and the period of such oscillations or the length of time required to make one complete oscillation is called the natural period of the body.

A body may also be forced to oscillate by the action of an impressed periodic force; that is, by an external force which recurs at equal intervals of time. For example, suppose that a shaft mounted in bearings carries an eccentric weight. When the shaft is revolved at any given speed this eccentric weight produces a centrifugal force, which produces kinetic reactions at the bearings and thereby causes the supporting system to oscillate back and forth. This forced oscillation of the supporting system, of course, has the same period as the speed of revolution. Suppose that the speed of revolution is altered until the period of this forced oscillation of the supporting system is identical with its natural or free period of oscillation. In this case we say that the two periods synchronize. The result of such synchronism is to intensify the vibration greatly and, although in any actual case the amplitude of vibration cannot exceed a certain limiting value, it frequently becomes so large as to cause failure of certain parts or even tear the machine from its supports.

By critical speed, then, we mean that speed of the rotor which synchronizes with the natural frequency of oscillation of the supporting system; that is, the critical speed is reached when the number representing the revolutions per minute of the rotor becomes identical with the number representing the number of oscillations per minute which the supporting system would perform if set in vibration and left to itself.

Every elastic body has more than one natural period of oscillation. The vibrations corresponding to these higher periods are called harmonics. A familiar illustration is that of a violin string which, in addition to its fundamental note, can be made to sound overtones or harmonics by stopping the vibration with the finger at certain definite points called nodes. Every elastic system possesses such harmonics. Consequently, there is always more than one critical speed, the higher critical

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speeds corresponding to synchronism with these harmonics. It should be mentioned that these higher critical speeds are not simple multiples of the lowest critical speed, but bear a more complex relation to it, depending upon the nature of the system.

Causes and Types of Vibration

When vibration is due to centrifugal forces and centrifugal couples arising from unbalance, it can, of course, be reduced or eliminated altogether by balancing the rotating parts. But there are other causes for vibration which cannot be eliminated so easily. For instance, in an eight-cylinder V-type engine, a perfectly balanced crankshaft will not result in a perfectly balanced engine, as there are certain inertia forces arising from the reciprocating and semi-rotating parts which are not affected by balancing the purely rotating elements. Moreover, vibration due to synchronism is entirely distinct from vibration due to unbalance. The effect of unbalance is to produce kinetic reactions which are taken up by the supporting system, causing it to shake violently or vibrate. Whenever vibration is due to unbalance, it can always be traced to the kinetic reactions applied at the bearings of the rotor. Synchronism is a broader term and includes vibrations not due to unbalance or only indirectly due to it. Vibration due to synchronism may even affect machines which are not running. For instance, in one case at least it was found that the discs of a turbine rotor were vibrating, or fluttering, although the turbine was not in operation. This, of course, was due to synchronism between the natural period of the turbine disc and the operating speed of adjacent machinery. A perfect example of vibration due to synchronism is the response of a wireless receiving set to the vibrations sent out by the generating station. Clearly, such forced vibrations are due to pure synchronism and have no relation whatever to unbalance.

In the case of machinery, vibrations due to unbalance are often confused with those due to synchronism. The first esential to an intelligent understanding of this whole problem is to make perfectly clear the distinction between forced vibrations due to the kinetic reactions arising from unbalance and forced vibrations due to synchronism. For instance, it is perfectly clear to every one that an unbalanced rotor must produce some vibration of the supports, and that this vibration must be present at every speed, although, of course, it is worse at some speeds than at others. Now this supporting structure, which we will call structure No. 1, rests at certain fixed points in some kind of foundation, which we will call structure No. 2. At certain definite speeds, such as we have called the synchronous speeds, the vibration of structure No. 1 is communicated through the points of support to structure No. 2, and this effect does not depend on what causes the vibration of the first structure. We can, therefore, make the distinction that the vibration of structure No. 1 is produced by kinetic reactions due to unbalance; whereas, the vibration of structure No. 2 is due to synchronism with structure No. 1, independently of what causes the first structure to vibrate.

Elimination of Vibrations Due to Synchronism

When vibration is due to synchronism it is obvious that the cure is to destroy this synchronism. In the case of automotive apparatus, this means that a new principle of engine suspension must be introduced. For stationary machinery the same result can be accomplished by applying this new principle to the design of the understructure. The latter was discussed in a paper by N. W. Akimoff, presented at the annual meeting of the American Society of Mechanical Engineers, December, 1920.

The customary method of suspending an engine or mounting a machine consists in anchoring it down firmly to a support designed to be as rigid and massive as possible. There is no attempt to destroy synchronism, the idea being simply to reduce the amplitude of the motion as much as possible. But, in automobiles and aircraft, the entire support is elastic and comparatively light, the result being that the whole structure vibrates freely with the same period as that of the engine. Moreover, in the case of heavy machinery rigidly anchored to heavy foundations, although, of course, the amplitude of the motion is decreased, the mass that is set in vibration is greatly increased, so that we now have the case of a

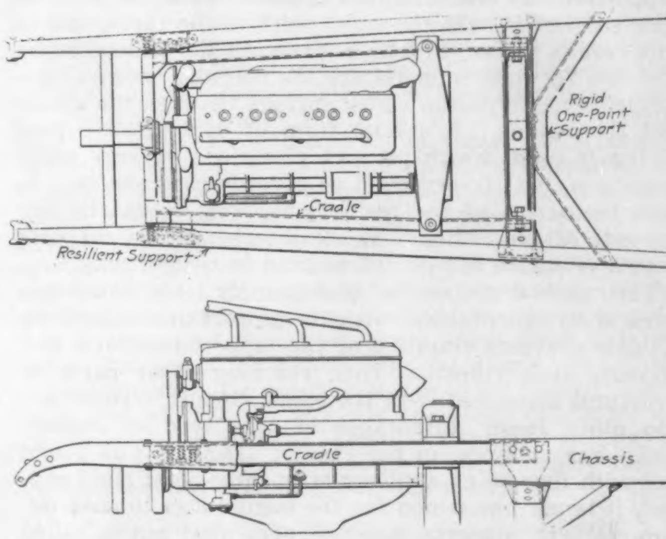


Fig. 1—Application of the Three-Point Principle of Support to Automotive Apparatus

large mass vibrating with a small amplitude. Since the energy absorbed is proportional to the mass of the body, it is evident, particularly in the case of synchronism with the support, that the power loss is not cut down exactly in the same ratio as the amplitude is reduced. It is mentioned in passing that this question of synchronism is one of the vital problems in electrical engineering at present.

It is obvious that the true solution of such problems can only consist in destroying this synchronism by isolating a machine from its support so far as the transmission of vibrations is concerned. To explain what this implies, it is pointed out first that any body may have at most six degrees of freedom; that is, it may be free to move along any three mutually perpendicular axes, giving three degrees of freedom, and it may also be free to rotate about these three axes, giving the remaining three degrees of freedom. If one point of the body is fixed, this destroys the first three degrees of freedom since the body can no longer move as a whole in any direction; but it is still free to rotate about any axis through the fixed point, so that it still possesses three degrees of freedom as regards rotation.

To apply this to the present case, suppose that one point of an engine or a machine is fixed, so that it can pivot about this point. Suppose that, in addition to this one fixed point, two other points of the machine are mounted on resilient supports. It then is evident not only that the machine will have three-point support, but

also that within certain limits it will have freedom of motion about the fixed point, due to the resiliency of the other two supports. This type of three-point support, one point being rigidly fixed and the other two supports being elastic or resilient, leaves the body three degrees of freedom, and yet makes it possible to control absolutely the period of the vibration. In other words, by properly designing or adjusting these resilient supports it is possible to change the period of vibration so as to prevent any possibility of its synchronizing with the natural period of the engine bed or foundation.

Application to Automotive Apparatus

Fig. 1 on page 55 shows one method of applying this principle to automotive apparatus. The method used in this case consists in mounting the engine in a cradle, and supporting this cradle on the chassis at three points. The rear support is here the rigid point of the three, and in this case is placed directly underneath the transmission. The two forward supports are the resilient ones and are formed by interposing coiled springs between the cradle and the chassis. A special form of double telescoping spring is used, which permits vibrations of very small amplitude, but is very rigid as regards road shocks. In fact, the action of the resilient supports is exactly the opposite of the ordinary shock absorber. The supports absorb vibration but do not respond to road shocks.

This method of suspension absolutely isolates the machine from synchronism with its support and, therefore, not only prevents vibration of the support itself but also prevents such vibration from reaching other parts or structures connected with the same support. There are also other lesser advantages of this type of suspension. For instance, in the case of tractors it is found that with four-point, and even with three-point rigid support, it is not uncommon for the engine lugs to snap off. Two resilient supports, however, give what can be called a full-floating suspension, and relieve the crankcase of any abnormal strains to which it may be subjected when all the supports are rigid. It should be mentioned again that the resilient supports are actually very stiff, although not rigid in the same sense as the frame itself, their purpose being to prevent synchronous vibration, but not to permit relative motion to any extent.

There have been several attempts to solve this same problem by using various forms of spring suspension, but none has been based on the scientific principle here used, which consists in destroying three degrees of freedom and allowing the other three to remain. For instance, one man tried three spring supports, another tried four and a third used a cradle mounted at the rear end on an axle transverse to the frame with two spring supports at the forward end, thereby allowing but one degree of freedom. Such forms of suspension cannot yield satisfactory results, as they are wrong in principle. It is apparent from what precedes that the principle underlying the design here described is radically different.

To sum up therefore, we may say that there are two main types of vibration, one due to unbalance and the other to synchronism. The first can be eliminated by well-known methods of balancing, leaving only the vibration due to torque recoil and inertia forces. The second can be eliminated by preventing synchronism, and this can be accomplished by introducing a new type of three-point suspension. The underlying principle consists in controlling the period of vibration by two resilient supports. By this means any machine can be completely isolated from its support so far as synchronism with any operating speed is concerned. This increases the life of the machine and also materially raises its efficiency, with but a very slight increase in cost, if any. It should be noted that this method of suspension supplements, but does not replace, careful balancing of all rotating parts; furthermore, that its use will improve the performance of any type of engine, although most needed by the four and eight-cylinder types.

CRUDE OIL

NEARLY all crude oils show more or less fluorescence and all show a red coloration when observed by transmitted light. With very dark or black oils it is necessary to examine thin layers to note the red color. One should remember that these colors are due to impurities, as pure hydrocarbons do not possess color. Crude petroleum may be almost as mobile as kerosene or it may be about as thick as "molasses in January." The proportion of light and heavy liquid hydrocarbons and the amount of solid hydrocarbons dissolved will govern the fluidity of the crude oil. Some crude oils have an odor much like that of gasoline or kerosene. Such a crude oil will obviously contain a large proportion of the lighter volatile hydrocarbons. Petroleum which is lean in light stuff may have almost no odor save that inadequately described as "oily." The heavier hydrocarbons when pure are practically odorless. If sulphur compounds are present, a crude oil will have a rather nauseating odor. It is difficult to describe these sulphurous odors, though they are sharp, very disagreeable and decidedly characteristic. Sometimes hydrogen sulphide gas is dissolved in the oil and its characteristic, rotten egg odor is very much in evidence. Crude oil may vary in specific gravity within rather wide limits, the proportion of light and heavy constituents governing this property. Some crude oils are very light with a gravity as high as 49.5 deg. Baumé, equivalent to 0.780. Others may be much heavier, with a gravity as low as 11.4 deg. Baumé, equivalent to 0.990, which is almost as heavy as water. Some few petroleums contain so much light stuff that they will burn in the ordinary internal-combustion engine. Naturally the continued use of such a fuel would be somewhat hard on an engine because of the impurities and the impossibility of obtaining complete combustion of the heavier hydrocarbons with a carbureter and an engine designed to handle only light stuff.

Most of the oil wells of the United States today are being pumped. As the oil comes from the earth it may or may not be mixed with considerable water, suspended mineral matter and "bottom settlings." The latter consists of inert organic matter mixed with finely divided mineral material. Some oils are mixed with a great quantity of water, either fresh or salt, and practically all carry a small amount.—C. J. Frankforter in *Oil News.*

A MILESTONE OF AUTOMOTIVE PROGRESS

THE Studebaker Corporation, South Bend, Ind., has discontinued the building of wagons. It will continue to produce and supply repairs for the many Studebaker wagons in use. Thus will pass from the market one of the oldest and best-known farm wagons. The discontinuance of this line reflects the progress of the motor vehicle.—*Farm Implement News.*

TRADE BALANCE

AMERICA'S trade balance cannot be definitely calculated from the excess of our exports over imports. If our enormous foreign loans are taken into consideration, the actual exports of this country could drop very much lower than they have without impairing our real trade balance.—O. P. Hopkins, Bureau of Foreign and Domestic Commerce.

Inspection and Testing in Interchangeable Manufacture

By EARLE BUCKINGHAM[1]

WITH any system of inspection the tendency of the productive departments is to neglect all thoughts of the ultimate use of the parts in process and to concentrate on efforts to increase production, the standard of quality apparently being anything that the inspector will not reject. Thus, an unfortunate situation almost inevitably arises, the production departments considering only the detailed manufacturing problems and constantly seeking the line of least resistance as regards the machining, while the inspectors either connive at this or arbitrarily insist on the exact letter of the drawings and specifications without regard to the ultimate use of the part in question.

Neither of the above forms on inspection is satisfactory. Seldom, if ever, are the drawings and specifications complete or correct enough to be followed blindly. The mere meeting of the drawing requirements is not in itself the prime object of manufacturing. The main purpose in all branches of interchangeable manufacturing is to promote the economical production of satisfactory mechanisms. If the inspection is to accomplish its part in this work discretion should be used, and due consideration should be given to many factors.

DISCREPANCY BETWEEN PART AND DRAWING

When a piece of work is not in accordance with the component drawing, any one of several conditions may be present; (*a*) the part may be wrong and the drawing correct; (*b*) the part may be correct and the drawing in error; (*c*) both the part and the drawing may be correct, and (*d*) both the part and the drawing may be wrong. In the first case, if the part cannot be salvaged, it must be scrapped. In the second case, the part should be accepted and steps taken immediately to have the drawing corrected. The third case requires more consideration. For almost every problem there is more than one satisfactory solution. If the part as completed can be reproduced at a lower cost than one made in accordance with the drawing, the part should be accepted and the drawing corrected accordingly. But if the part as made is more difficult to reproduce, the drawing should remain unchanged, although the part need not be rejected. In the fourth case, if the part cannot be salvaged, it is, of course, scrapped, but the necessary corrections should be made on the drawing as soon as possible.

In all of this work, due consideration must be given to the succeeding manufacturing operations and equipment provided for performing them. When elaborate manufacturing equipment is provided, it is often cheaper to scrap parts that might otherwise be salvaged, because of the difficulty of completing them with the existing equipment. It is obvious that when a great volume of production is involved discretion can be exercised by but a few of the inspection personnel. Hence any abnormal volume of rejections by the inspectors should be the occasion for a reinspection of the rejected parts by persons competent to locate the error, whether in the parts or the drawings. The original drawings seldom give information complete in every detail which is necessary to produce every part. The production departments, however, must complete the parts with or without the assistance of the drawings and specifications, while the inspection department must decide whether or not the parts thus produced are satisfactory. The first solution of some of these indefinite points may not be the best one, and several different methods may be tried out before one that is entirely satisfactory is reached. During all this development, the inspector must give earnest consideration to the problem, so as not to delay production unnecessarily and still insure a satisfactory product. As soon as any problem is solved, the inspection department should be responsible for passing the information along to the proper persons so that it may be recorded.

This makes it clear that the inspection department, among its other duties, must act as eyes for the engineering department. For this reason, in some plants the inspection department reports to, and is virtually a part of, the engineering department. In other plants, it is a distinct department and is responsible to the managament. Either plan usually works out well. In no event should it be a part of, or subordinate to, any production department. The duties of the production and the inspection departments are so incompatible that they should never be combined, and if they are, one or the other is bound to suffer. Nevertheless, the inspection should be carried on in close cooperation with the production departments, as well as with all other departments of the organization.

The mechanical inspection of component parts falls logically into two main divisions. The first is the shop inspection which is performed while the parts are in the process of manufacture. The object of this inspection is to cull out defective work as early as possible and to discover any defects in the manufacturing equipment which result in faulty work. The second division is the final examination of the completed parts. The object of this is to see that all components that will function properly are accepted, and all unserviceable parts rejected. There is also the inspection, or testing, of the assembled mechanism to detect faults that have not been detected prior to assembling the parts.

SHOP INSPECTION METHODS AND PERSONNEL

When the production is continuous, the shop inspection should be established so that the parts are rigidly inspected after each machining operation on every important functional surface. The requirements of these surfaces should be definitely determined and recorded as early as possible, and these requirements should be rigidly maintained. These inspections are as important as any of the productive operations, and should be maintained accordingly. The inspection of non-functional and other unimportant surfaces can usually be handled by an inspector who passes from department to department and periodically checks a small percentage of the product at each machine. If any errors are discovered, the machine should be stopped and the set-up corrected, but the parts at fault should not necessarily be rejected. The inspectors are, of course, supplied with the necessary gages, limit gages being essential for most of the important functional surfaces, while "go" gages alone are usually sufficient for surfaces of lesser importance. Definite lists of the essential inspections or important functional surfaces should form a part of the specifications. These may be combined with the operation lists or may be made up as separate schedules. Whether or not each individual piece of work should be inspected depends largely on the character of the operation. On many automatic operations, a percentage inspection is sufficient, while on most hand operations, where each piece is handled individually and the personal skill of the operator is a factor, a 100 per cent inspection is usually required.

The inspection of screw-machine parts made from bar stock is the case where the inspection of a minor percentage is sufficient. The practice in one plant is as follows: Each automatic screw machine has, as part of its equipment, several small metal work boxes or baskets which are numbered consecutively. These are used in order, and about every 15 min. the one on the machine is removed and placed

[1]M. S. A. E.—Engineer, Pratt & Whitney Co., Hartford, Conn.

on a bench, while the one with the next number is placed on the machine. An inspector makes periodical visits and inspects a few parts from each basket. If these are satisfactory all the parts are removed and the empty basket is returned to the machine operator. If a faulty piece is found in any basket, the entire contents of that basket, all succeeding ones, and also the one preceding it, are set aside for a 100 per cent inspection while the machine is stopped immediately and its set-up corrected.

This general plan is adaptable to many other operations, such as sub-press die work and other punch press operations, for example, where the set-up and conditions of the tools alone practically control the uniformity of the product. The shop inspection should be carried on as soon after the machining operations as possible. In the case of very large parts the piece is often inspected before it is taken from the machine, which saves a new set-up if corrections are necessary.

Much of the detail work of testing the parts with gages, particularly on small work, requires little mechanical knowledge or skill, and is often satisfactorily performed by girls. When the quantity of production is large, and the inspections are subdivided into elementary tasks, a relatively small amount of training will develop efficient detail inspectors. The supervisor of such work, however, should be not only a good mechanic, but also a person well acquainted with the requirements of the product. The successful chief inspector must be firm but diplomatic; his duties must never degenerate into fault finding.

The person in charge of the shop inspection has one of the most difficult positions to fill. A great part of his work in promoting economical production is to prevent faulty parts from being made. When an operation is first set-up, the product should be checked. If it is satisfactory, the succeeding parts must be watched, so that the set-up may be corrected before any work is spoiled. If the first parts do not meet the requirements, the set-up must be corrected before production in quantity is started. To fulfill these duties properly, without antagonizing those engaged in production, is a delicate task and the closest coöperation is necessary. An arbitrary inspector will soon stop production entirely. On the other hand, an inefficient inspector can soon ruin the repuation of the firm. A grave mistake on the inspector's part in either direction will inevitably cause much needless expense.

Final Inspection of Work

In many ways the function of the final inspection is very different from that of the shop inspection. The latter deals with the parts as they are being shaped from the raw material. Nothing should be left undone to promote their completion in accordance with the drawings and specifications. The final inspection, on the other hand, deals with the parts after all the machining operations have been completed. Its main function is to see that all parts which will give satisfactory service are accepted, and that those which will not are scrapped. This result alone should be striven for, regardless of technical violations of the drawings and specifications. Under normal conditions, such violations should be rare. If conditions are abnormal, steps should be taken to correct them, but such steps should never involve the rejection of serviceable parts.

In general gages used in the final inspection should be functional gages only. If the detailed shop inspection is properly organized, there is no need to duplicate it here. If it is not functioning properly, the trouble should be corrected at its source. Both the shop inspection and the final inspection should be under the general direction of the same person. All final decisions as to the acceptance of questionable material, whether questioned by the shop inspection or the final inspection, should also be made by the same person.

One of the duties of the inspectors who perform the final inspection should be to watch the work of assembly in addition to testing the assembled product. If the component parts assemble properly and the completed mechanisms function as they should, no further evidence is needed that the productive work has been properly done. If the parts give trouble in assembling or the mechanism fails to function, immediate steps should be taken to locate the trouble and correct it at its source. Thus the assembling departments form the best points of advantage to watch and judge the results that are being obtained.

The inspection of the gages used in the course of manufacture is one of the vital functions of the inspection department. As gages become worn, they permit parts larger or smaller, as the case may be, to pass inspection. The adjustment of a machine or tool is not changed as long as the parts produced satisfy the gages used in their inspection, and so all gages should be checked periodically and corrected or replaced as found necessary. Too often this is not done until trouble has developed. One of the principal objects of inspection is not to locate the cause of trouble after it has happened, but to forestall and prevent it. A systematic inspection of gages is one of the surest means of accomplishing this end.

Most of the inspection of the composition and physical strength of materials belongs in the chemical and metallurgical laboratories. When a part is subjected to unusual stress, it is customary to make a chemical analysis of each bar of stock as it is received. This and other specified physical tests are seldom considered in connection with the mechanical inspection of the product. Often, however, after such operations as forging, hardness tests are made in conjunction with the other inspections to insure that the metal is in proper condition to be readily machined. Such tests are usually made with simple testing instruments, such as the Brinell testing machine or a scleroscope, the mechanical operation of which require no more skill than the proper handling of gages, and are, therefore, usually conducted by the regular mechanical inspection personnel.

Whenever possible, the assembled mechanism is tested by actually having it perform the work it is intended for. Thus, a newly completed automobile is usually sent out for a road test before being shipped; a typewriter is manipulated by an operator; a rifle is tried out by a marksman, etc. These tests, of course, only prove the condition of the mechanism while new. The test of service depends upon the materials used in its construction and the honest workmanship which has been built into it at every stage beginning with the designing and followed by the careful and watchful work of the productive operators, the vigilance and good judgment of the inspectors and the care and attention of the assemblers, No one factor is predominant. All are essential and each one must be carefully studied to develop and maintain a smooth flow of production.—*Machinery.*

RADIO TELEPHONE

THE growing usefulness of the radio telephone in its application to aviation exemplifies itself every day. By enabling the flier to keep in constant communication with the earth, it gives him speech and hearing and, by so doing, keeps him apprised of weather and other conditions ahead. The psychological effect upon the flier of this invisible link with the earth, this intangible evidence of "human touch" is incalculable. To a very decided degree it reduces the sense of hazard as it actually minimizes the danger by affording him indubitable evidence of the physical conditions to be encountered throughout his route.

In recognition of its importance to aviation, the Belgian, French and British governments have established a line of the phone stations along the Paris-London and Brussels-London air routes. Stations now operating are located at Croydan just outside of London, at Lympne on the English side of the Channel, at a point off the French coast and at Paris. Preparations are also in progress to establish other stations at convenient intervals in England and France.—Air Service Letter.

Some Inland Waterway Transportation Problems

By V. E. Lacy[1]

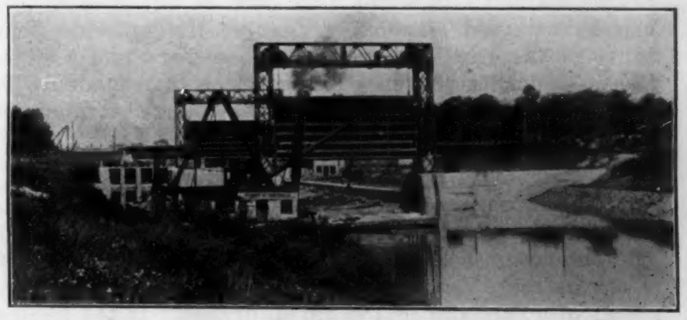
Semi-Annual Meeting Paper

Illustrated with Photographs

THE problems of inland waterway transportation are more a matter of public education than anything else. Given the waterway on which suitable boats can be navigated, the problems of the vessels themselves and their methods of propulsion are by no means difficult. To arouse proper public interest in water transportation is the one big problem. The American public has become so thoroughly educated to the railroad as a means of inland transportation that it is very difficult to bring it to the point of thinking about waterways boat transportation. Even at this time of serious transportation congestion, caused by the inability of the railroads to handle the freight offered, it appears that comparatively little is being done in the way of developing waterway transportation. It is increasing but in nothing like the proportion that is possible.

Combination Mohawk (at the Right) and Sector Gate (at the Left) Dam at Rochester, N. Y., Forming the Harbor by Raising the Genesee River to the Canal Level

It is reported that for the first month of 1920 navigation on the New York State Barge Canal the tonnage passing Troy was 94 per cent greater than for the same month of 1919. It is reported also that all of the available boats are in service on this waterway and that much more tonnage is being offered than these boats can accommodate. That so much freight is being offered for water shipment over this route is most encouraging. The discouraging element is that little has been done to provide the necessary boats, and little is heard in the way of reports of projects for the future. The total of boats operated on this canal in 1920 will probably not exceed 500. The capacity of the canal would not be reached by operating 10 times this number. In the palmy days of the old Erie Canal there were 6000 boats in operation and the new canal has many times the

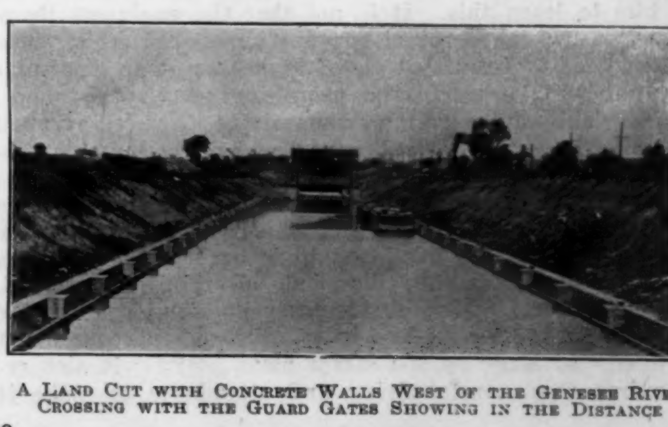


Guard Gates at Each Side of the Genesee River Crossing, Their Use Being Made Necessary by the Fluctuations in the Level of the River

capacity of the old one. Of course, a few new boats are under construction and several corporations along the canal are making preparations for fleets to transport their raw materials and finished products to and from their works.

The problem of motive power for canal barges is a large one. The ideal propulsion has not been developed yet. But the means at present available are sufficiently satisfactory to avoid delay by waiting for the development of the ideal motive power. In my opinion the internal-combustion engine in some form will be found eventually to be the most desirable power. At present, however, little thought is being given to any power other than steam. The great advantages of steam power are its flexibility and the development of great power at very low rotative speeds. The latter is highly desirable because the greatest propulsion efficiency for towing and driving heavy barges at low speed is attained by means of a slow-turning, large-diameter and comparatively low-pitch propeller. It seems that extreme flexibility and low speed are the only really important advantages of steam over the internal-combustion engine.

Viewing the problem from the standpoint of the



A Land Cut with Concrete Walls West of the Genesee River Crossing with the Guard Gates Showing in the Distance

[1]M. S. A. E.—President, Rochester Boat Works, Inc., Rochester, N. Y.

internal-combustion engine, the question arises as to what form of this type of engine would be most suitable. In respect to flexibility the gasoline engine is by far the best, but it cannot be considered for this purpose on account of the high cost of its fuel. Other difficulties with large gasoline engines will readily come to mind. Two types of internal-combustion engines offer great possibilities for canal-barge propulsion. These are the heavy-oil engine and the gas engine taking its fuel from a producer. It is certainly possible to develop either of these types into a wholly satisfactory powerplant for this purpose. The chief difficulties are to secure the desired flexibility and to keep the speed down to the point where proper propeller efficiency can be maintained. It seems that both of these conditions can be attained reasonably closely; the extreme flexibility of the steam engine is not necessary and a slight loss in propeller efficiency can be more than made up by the greater thermal efficiency of the internal-combustion engine.

Canal-Barge Engine Requirements

To meet the required conditions the engine must be a heavy slow-turning one capable of a wide range of speed. The full-power speed should not exceed 250 r.p.m.; 200 would be more desirable. A steam engine would operate at probably 120 to 150 r.p.m. or less. If the engine operated at 200 to 250 r.p.m. at full load, it should be capable of throttling to 75 r.p.m. This would, of course, necessitate a very heavy flywheel, unless a multiplicity of cylinders were employed. In this connection, the number of cylinders should be as few as possible, but in my opinion there must be three, and the next and only other step is to employ six. The three and six-cylinder engines possess the necessary features to provide suitable reversing means, whereas a four-cylinder engine does not possess them except when it is of the two-cycle type, when the cranks can be set at 90 instead of at 180 deg.

One object in using a small number of cylinders is to reduce the length of the engine. Another is increased simplicity, which is very desirable because the class of men who will operate the engines are not capable of taking proper care of an intricate piece of machinery. More cylinders necessitate more bearings and a greater number of other working parts, requiring a higher type of man to keep everything in proper order. A multiple-cylinder gas engine in its simplest form is more or less of a puzzle to the steam engineer who has spent his life alongside a single non-condensing or compound-condensing steam outfit. All things considered, a good gas engine is easier to keep in condition than a steam outfit of similar power and relative excellence, but the old-time steam engineer does not think so and it is very hard for him to learn this. It is not that the engineers themselves will be recruited largely from the ranks of those devoted to steam, but those higher up, who determine what will be used as a propelling power, are almost invariably steam-engine sympathizers. Something must be shown them that will appeal as being a suitable substitute for the steam engine.

Concerning the question of oil versus producer gas there seems to be no reason why perfectly satisfactory plants cannot be developed in either type. Each has advantages over the other but, all things considered, their general desirability is probably about equal. The producer is more-or-less bulky, although of course not nearly so large as the steam plant boiler. It also requires very careful firing and attendance to make it deliver a satisfactory gas; it is by no means a device to be put into the hands of a novice. From the standpoint of economy it is likely that a producer plant would deliver power at a lower cost per horsepower than any other. The oil engine would be a close second. With regard to first cost the producer plant would, I think, have a slight advantage over a first-class oil engine of the Diesel type. In the matter of weight there would not be much difference. The massive proportions of the Diesel engine would probably be more than duplicated by the producer. In either case the weight would be less than that of an equal steam plant with its boiler full of water and, of course, the space occupied by either would be much less, thus giving greater cargo capacity. In point of space occupied, the oil engine has the advantage. Power for power there would be but little difference in the actual size of the engines, whereas the gas plant must have space for its producer.

Reversibility

Reversibility is a matter of great importance when considering any form of internal-combustion engine. It is the one bugaboo of all types of marine gas-engine. In small marine plants this is taken care of in a fairly satisfactory manner by means of gears of various designs, but for engines large enough to propel canal barges and tow two or three others the gear method seems to be out of the question. The alternative is the reversible engine.

Reversing is most often accomplished in existing designs by some method of shifting cams; that is, two sets of cams are arranged along the same camshaft or shafts. One set is for forward drive and the other for the reverse. To engage either of these sets of cams, the camshaft is usually arranged to slide. This is done in smaller plants by a hand-lever or wheel and in larger engines by air-pressure. Starting in either direction is generally accomplished by air pressure admitted to the cylinders. Usually this is by means of a set of cams in a distributing device. This consists of a common chamber connected to the air-pressure tank and a series of poppet valves admitting air in suitable sequence into a series of pipes leading to poppet valves in each cylinder. The cams must be arranged to shift suitably simultaneously with the main cams for reversing the motion. Whatever system is used for reversing, it is requisite that it be absolutely positive. There must be no chance of the engineer failing to answer the signals from the pilot-house. It will, of course, be granted that no device or system can reverse a gas engine as quickly as a steam engine can be reversed, but, with a positive means of reversing with reasonable promptitude, no trouble need be experienced, as the man at the navigating end of the ship can easily learn to figure on what to expect from the engine-room. In working a boat through a canal with its multitude of locks, there must be no doubt about the navigator getting the results he signals for. Failure to reverse is likely to be very serious and far-reaching. Since starting the engine in either direction is usually accomplished by air pressure, both direct-connected and auxiliary means of providing compressed air and tanks for storing it must be provided. This system of compressors and tanks should be of about three times the capacity which might be expected to serve under normal circumstances. The designer must consider the conditions of crowded harbors and see to it that air-pressure will be always adequate when signals come down to the engine-room thick and fast.

A very simple means of reversing is possible with the

producer-gas engine. It is a method that ought to work out very satisfactorily. It consists of an arrangement of the exhaust and intake manifolds in which, by means of suitable valves, their purposes are reversed for reverse motion of the engine. In this case the manifolds are made alike in every respect. The valve arrangement would serve to cut either manifold into gas and the other into exhaust, depending upon the direction of rotation required. Linked up with this valve-operating system means would be provided for shifting the air distributor suitably. The main exhaust and intake cams can be alike, or, for better efficiency in forward drive, they can be designed with special reference thereto, and the reverse can be allowed to take care of itself, provided, however, that there is not so much difference in the cams so as to make them impracticable when used for opposite purposes. It is not likely that this would be the case. This reversing system has been worked out in a manner which seems perfectly feasible.

Power Required

The amount of power necessary for a canal barge depends, of course, upon the size of the barge and the number of tow barges it is intended to haul. The New York State Barge Canal was designed for barges of 1000-ton carrying capacity. The locks and all other elements of the canal are large enough to accommodate much larger vessels, but the consensus of opinion among experienced canal men is that vessels of about 700-ton capacity are the most desirable. These barges would be operated in fleets of four, a power barge and three consorts. When operated in this way, if the whole fleet is to lock through at one time, the boats would be about 140 ft. long, 21 ft. beam and 12 to 13 ft. depth of side. The boats, loaded, would draw from 9½ to 10 ft. of water, and the fleet would just nicely work through the locks, which have a length of 310 ft., width of 45 ft. and depth of water over their sills of 12 ft.

About 500 hp. would be required for a power barge of the size mentioned to be operated in the manner stated. This amount of power would probably propel the fleet 5 m.p.h. If greater speed should be required, more power would be necessary of course. But great haste is not usually essential in the transportation of such freight as these barges will handle. Economy is the important consideration and an additional mile or two per hour would add very greatly to the cost of propulsion when considered from the standpoint of the cost of power only. The desideratum is to arrive at a proper balance

One Steamer and Four Government Steel Barges Just Filling a Lock Which Has a Lift of About 16 Ft., the Time of Locking Through Approximating 30 Min.

A Lock Powerhouse Where Waterpower Is Used to Generate Electricity for Operating the Lock Gates

of the elements of fuel cost and operating cost. Too slow a pace would run into great expense in wages of crews; and if too much speed is attempted, the fuel bill will run up. The limit of speed on a large part of the canal is 6 m.p.h. and in some places 4 m.p.h. In the canalized river stretches a speed of from 8 to 10 m.p.h. is allowed. It is not likely, however, that a speed of over 6 m.p.h. will be found economical in the long run.

At this time anything in the way of a good barge from 250 tons up can, if properly fitted out and suitably propelled, be operated at a good profit. Shippers, barge builders, engine builders and their associated industries should work out the problem of water transportation. If the matter is energetically attacked by all interested, it will be but a short time before very material relief from the present congested traffic conditions will be felt. Anyone who will carefully study the map of the eastern half of the United States will be literally astounded at the possibilities of inland water-transportation development. We have several very fine routes ready for use, but have only scratched the surface of the ultimate possibilities.

THE DISCUSSION

G. R. Pennington:—Why is it that so few boats are operating on the canal?

Mr. Lacy:—The old canal became too small for commercial use in that the old canal boats were not especially economical as compared with other modes of transportation. The State decided to build the new canal and during the process the navigation on the canal was destroyed. Since that time the public has withdrawn its attention from inland water navigation. The unfortunate feature is that no adequate preparations have been made for the building of new boats. Very little boat building is going on. There is considerable activity in the way of making plans at present, and it is hoped that many new boats will be brought out. All available boats are running now.

Mr. Pennington:—How are the boats propelled?

Mr. Lacy:—They have mechanical propulsion of some kind; it is mostly by steam and largely by tug boats. I predict that the internal-combustion engine will be the future powerplant for driving canal boats.

A. K. Brumbaugh:—How are the barges in tow arranged? Has any difficulty been found at the curves of the canal?

Mr. Lacy:—There has been no difficulty. It has been proposed that very large barges be built that would practically fill the locks; barges approximately 275 to 300 ft. long and 40 to 42 ft. beam. Old canal men say that such barges would be very impractical, owing to their unwieldiness and inability to make the turns. The shorter boats can make the turns because one boat is put

behind another and a means of steering is provided by bending the fleet, one boat acting as a rudder.

MR. BRUMBAUGH:—Hs any difficulty been experienced with the dam construction?

MR. LACY:—It has been very successful, having passed through several winters. Some of the dams or the Mohawk River have been in operation for seven or eight years. Everything has worked out satisfactorily. The New York State Barge Canal is a wonderful piece of work. It is a fine structure from beginning to end.

WALTER C. KEYS:—What did the barge canal cost?

MR. LACY:—It has cost approximately $200,000,000 to date.

MR. PENNINGTON:—Who operate on the barge canal; individuals or corporations?

MR. LACY:—Either. There is no limit to the size of corporation that can operate on the canal at present. Formerly corporations were limited to $50,000 capital.

MR. PENNINGTON:—Does the traffic pay any part of the fixed charges resulting from the cost of building the system?

MR. LACY:—There are no tolls.

MR. PENNINGTON:—Why is it that the traffic does not build up rapidly?

MR. LACY:—The canal has been operating only two years; the large barges could not navigate the full length of the canal before 1918.

MR. PENNINGTON:—Is the War Department still in control of the canal?

MR. LACY:—Yes.

PLOWS

ONE who reads history and then looks out over our factories and fields to-day can scarcely realize that our industrial era is barely more than a century old. No one who goes through the country and notes the great array of farming implements for every farm operation can realize that as short a time as 85 years ago there was not a single really good plow in all the world.

The old-style plows of Europe and Asia merely broke and stirred the soil; they did not turn a clean-cut furrow. Mostly they were made of wood with a bronze or iron point. The moldboard was either lacking or was a crude affair of wood that did nothing more than push the soil aside. In medieval times the French had a clumsy two-wheeled plow which was used without change for centuries. This plow was improved somewhat by the Dutch in the seventeenth and eighteenth centuries, but the first notable advance in the art of plow-making was made in England when Foljambe took out the first patents which improved the Dutch plows. He is said to have been the first to use a plow clevis.

Later on a Scotchman, in 1763, established a plow factory and began to make iron plows. The body and handles were of cast iron and the share was made of wrought iron. These were the justly famous East Kothian plows. Another improvement was made in these plows in 1803, when Robert Ransome developed a process of casehardening the moldboards.

Charles Newbold is said to have taken out the first American plow patent in 1797. He produced a cast-iron plow and spent upward of $30,000 trying to get it established, but failed because of the prejudice of the farmers. The next American to undertake the manufacture of plows was Jethro Wood, in 1819. His chief contribution to the art was the principle of the interchangeability of parts. This ushered in a new era not only in plow-making, but in manufacturing generally. His plow was rather crude and consisted of a soft gray iron moldboard supported upon a wood framework.

Up to 1840 most of the land under cultivation in America was largely new land or land that was full of sand and gravel. It was easy to cultivate because it was full of humus and vegetable mold, as is all new land. The farmers managed to get along somehow with the old crude plows when the soil was young, but as it grew older troubles developed. The plows did not scour so well where clay predominated, while in sandy and gravelly soils they wore out rapidly. These plows were heavy and crude. They did not turn the furrow very cleanly, they were difficult to keep in the ground and they required much more power than modern plows. Still, despite these obvious handicaps, the farmers of those days managed to get along very well until the tide of immigration carried the first settlers westward to the prairies of Illinois. Here they found a soil that refused to scour with any of the plows which they carried with them from the East. The sod was tough, and below this sod was gritless soil as fine as flour and as sticky as dough. An empire awaited development, an empire of the richest land in the world, but it was practically valueless with the tools the farmers had to work with.

Many experiments were undertaken, but it remained for a humble blacksmith of what is now Chicago, John Lane by name, to find the solution. He conceived the idea of a steel moldboard in 1833. The solution of the soil problem had been found. It was not until about 1840 that the rolling mills recognized the infant industry sufficiently to roll special plates 12 in. wide, for plow moldboards.

In those early days all the blacksmiths in Illinois and the Middle West were plow-makers. They carved out the wooden moldboards according to their individual ideas of proper form and then faced them with boiler plate or steel. In 1837 a young Vermonter with initiative and mastery of the art of blacksmithing settled at Grand Detour, Ill., and started making steel plows. This was the real beginning of the steel-plow industry, an industry that ranks in national importance with harvesting machinery and our transportation systems in the development of the nation's resources. Without the steel plow the Mississippi Valley could not have been put so quickly under cultivation and the Prairie States would not yet be developed.

Deere, at Moline, and Parlin, at Canton, were responsible for the development of the steel plow in America. In 1868 John Lane, Jr., the son of the man who first used a steel moldboard, invented soft-center steel, an epoch-making discovery that lifted the steel plow industry to new heights of efficiency. In 1855 James Oliver bought a small foundry at South Bend, Ind., that had been making cast-iron plows for a number of years. They were clumsy, heavy and the moldboards were too soft. He had visions of a moldboard without fault or flaw, glass-hard and polished like a silver mirror. He succeeded in developing such an implement. He knew that the secret of success lay in discovering how to make a chilled casting that would be hard yet not brittle, and one that would be free from blowholes. He laid the foundation for an immense industry.

The development of the plow, especially the multiple-bottom plow operated by horses or tractors, has been revolutionary in its effects not only upon agriculture but upon all other forms of industry. It has released millions of men from the task of preparing soil for the crops and has thereby been a powerful factor in building up American manufacturing industries to their present position of prominence.

The reign of the crooked stick has been a long one. It still holds sway among hundreds of millions of peoples. We discarded it more than half a century ago and since then our progress has been rapid. When all the world does likewise we shall witness a new order of things with undreamed-of possibilities for good or evil, for the plow is a revolutionary implement.—P. S. Rose in *The Country Gentleman*.

PETROLEUM FROM SHALE

THE principal commercial oil shale is generally known as torbanite. This name is derived from the Torbane Hill mine, Scotland, where the shale was first mined and retorted successfully. It is a brownish or dark black, fine-grained, schistose shale having a fawn-colored streak without luster and a subconchoidal fracture and gives off curled flakes like shavings when scratched with a knife. Sometimes it resembles coal and occurs in bedded deposits in similar formations. On many of the oil-shale fields, like those of Nova Scotia, Newfoundland, Scotland, New South Wales, Colorado and Utah, coal seams exist above the shale beds. Oil shales occur also in irregular blocks interspersed in sedimentary deposits, but such deposits are of little commercial importance.

The usual solvents for paraffin and resin do not dissolve anything from oil shales. This indicates that petroleum bitumen and paraffin are not contained in the shales in a free state. The organic matter on being attacked by the metallic oxides has been converted into an insoluble carbonaceous compound known as kerogen.

There appears to be a graduation in oil content from peat up to the highest grades of torbanite. The paraffin and oil contents of peat are small, of bituminous coal moderate, and of torbanite high. Some of the torbanite from New South Wales carries as much as 125 gal. of oil per ton. It is also found that the crude oil content diminishes and the ammonia increases proportionately with the age of the shales.

Shale Mining and Distillation

The shale beds are mined exactly like coal deposits. Some of the large commercially valuable deposits outcrop on the surface, like the Newfoundland deposits, and can be openly quarried. Other deposits are deep in the earth and are covered by other rock formations. These have to be developed by the sinking of vertical shafts. The principal deposits now being operated are in inclined beds and are mined through slopes following the angles of the dip. When the mines are opened out by shafts or slopes, levels are run and connected together as in coal mines. Then the beds are prepared for working either on the long wall or the pillar and stall system.

The United States oil-shale deposits are widely distributed in Texas, Nevada, Colorado and Utah. The Colorado and Utah deposits outcrop in immense beds which in places are over 150 ft. in thickness. An acre of this shale is estimated to carry about 25,000 bbl. of oil. Many of these deposits can be cheaply worked by quarrying and surface excavation. But many important scientific problems have to be determined before the oil can be commercially extracted from the shale.

The oil shales in America are dissimilar to those of Scotland which have been profitably mined and distilled for many years. In Scotland, the oil shales are distilled in vertical retorts resembling iron blast furnaces. The distilling plants are always erected near the mines to save carriage costs. The shale, when taken out of the mine, is crushed into coarse blocks about the size of an ordinary brick. It is then fed into large hoppers placed above the retorts, but connected with them so that they can be automatically fed. The retorts are large brick and cast-iron stacks into which the shale is fed at the top.

The Bryson retort, used largely in Scotland, is a double shaft retort. It is 34 ft. in height. The bottom part, built of bricks, is 20 ft. high, and the remaining 14 ft. is built of cast iron. Each shaft is 15 x 33 in. in plan at the top and 22 x 56 in. at the base of the brick part. The retorts stand on a base of stone, concrete, or bricks about 20 ft. in height. In other words, the hopper feeds are 63 ft. above the ground. Each retort holds 15 tons of shale. At the base of the brick portion of the retorts there is a revolving cast-iron bottom which stirs up the shale and automatically discharges the spent shale into a hopper and on a revolving belt which takes it away to the spent shale dump. A single retort extracts the oil and ammonium contents from 4 tons of shale every 24 hr. Consequently, to handle 1000 tons daily, it is necessary to provide benches containing 250 retorts. The retorts are fired by gases from the distilling works, augmented by producer gas from coal. The gases given off from the shale are drawn into collecting chambers and passed through ordinary water-cooled pipe condensers made from 4-in. pipes arranged in long vertical stacks. Ammonia water and crude oil are collected in the condensers and drawn into tanks. In these tanks, the water settles while the oil rises to the surface and is drawn off into other tanks and separators. It is found that some of the gas cannot be condensed in the condensers. This is called the permanent gas. It is cooled in an ice machine and compressed in a power compressor. By these means a certain amount of gasoline is secured from it. The remainder of the gas from the compressor is stored in gasometers and is used for fuel purposes.

The crude oil, after being extracted from the shale, is treated as crude oil from oil wells is treated in the refineries. The refining processes and machinery are modified to suit local conditions met with at the different localities. The Scotch method of oil-shale distillation is quite unsuited for American conditions. It is too costly, slow and inefficient. Before the industry can be established here, an entirely new method of retorting must be developed. There must be means provided for handling large quantities of shale. Our inventors and experimenters are recognizing this. A recent patent covers a method for treating the shale in pulverized form in steam-jacketed pipes. The powdered shale is dropped into steel tubes heated with superheated steam. The volatile hydrocarbons are drawn off at different temperatures. By these means, ordinary retorting is avoided. The operation is really a straight distilling and refining operation in a single plant.

Form of Carbon in Shale

The Colorado Geological Survey is experimenting on some of these problems which must be solved before the oil shale industry of the United States can be firmly established. It finds that the Colorado shales appear to carry carbonaceous material in three distinct forms, and therefore require three different retorting operations. These forms are:

(1) True hydrocarbons in the solid form, occupying extremely small pits and intergranular spaces in the shale

(2) Plant, and possibly animal matter, which has undergone changes akin to those by which vegetable matter is converted into coal

(3) Fixed carbon

The relative proportions of these three materials are far from constant. In some rich shales the true hydrocarbons, probably paraffins, greatly exceed the other two materials. Such shales when examined under a powerful miscroscope show great numbers of grains of true hydrocarbons, and very little, if any, vegetable tissue. The fixed carbon content of such shales is generally low. On the other hand, there are shales in which the vegetable tissue greatly exceeds the hydrocarbons in quantity.

In retorting, the true hydrocarbons appear to vaporize at a comparatively low temperature, while a higher heat is necessary to develop hydrocarbon gases from the vegetable matter, and the last hydrocarbon gases are given off at a very high temperature. Whether these last come from the true hydrocarbons or from the altered vegetable tissue it seems impossible to determine. The fixed carbon cannot be converted into hydrocarbon gases unless, in some way, the necessary hydrogen is supplied, and it is doubtful whether the hydrogen and carbon can be made to unite under the conditions prevailing in the retorts. The shales are not simple homogeneous materials yielding their gases by volatilization at a definite temperature or within a narrow range of heat.

Tasmanite shales yield on distillation between 40 and 65 gal. of crude oil per ton and corresponding quantities of ammonium. The oil is very dark and viscous. The mining of tasmanite shales costs about $1.50 per ton and retorting costs 60 cents. The average return is about 40 gal. per ton.

The torbanite and tasmanite shales mentioned together with albertite constitute the three classes into which oil-bearing shales are divided. Albertite is a solidified mineral pitch, dark black in color, like hardened coal tar. The largest deposits of pure albertite occur in Albert County, New Brunswick, Canada. It yields between 90 and 120 gal. of oil, and 80 and 90 lb. of ammonium sulphate per ton. In many parts of the United States, in western Canada, Queensland and New Zealand there are large deposits of sandstones and shales richly impregnated with asphaltum which chemically resemble albertite.

American oil shales cannot be developed on any large scale without the investment of a tremendous amount of capital. Until economic conditions change and force us to utilize auxiliary oil resources, oil-shale developments will be of little commercial interest.—A. Selwyn-Brown in Sinclair's Magazine.

TRUNK HIGHWAYS

THE problem of the design of a highway from the standpoint of traffic resolves itself into a determination of the probable amount and character of vehicular traffic during a future period, the design of the grades, curves and width of the roadway so that it will be efficiently serviceable for the traffic which it is to carry; the determination of the amount and character of external forces to which the different parts of the highway are subjected and finally the design of the bridges, drainage systems, foundations and roadways so that they will have sufficient internal strength to resist the external forces during a reasonable period of time.

The forces, due to motor-truck traffic, which should be given consideration in the design of a roadway wearing course and its substructures are the direct load causing compression, impact forces, the shearing forces of the driving-wheels and the resultant forces between the subgrade and the pavement foundation. Necessarily these forces are functions of the volume, weight, speed and character of the vehicles using the highways. These factors are determined as a result of information furnished by highway transport surveys and legislative regulations covering these factors. The best indication which we have of the probable normal maximum weights of vehicles to which highways will be subjected in the immediate future is the recommendation of a committee of the National Highway Traffic Association which was adopted at the 1919 convention of the American Road Association and which was later incorporated in the proposed uniform vehicle law which is supported by several national organizations. The above recommendation pertaining to motor trucks allows a load per linear inch of width of tire of 800 lb. and a maximum gross load on four wheels of 28,000 lb. These limitations, which have been embodied in the laws of several states, allow the use of motor trucks having a capacity of 7½ tons. In this connection it should be noted that the Trailer Manufacturers' Association of America has advocated legislation limiting the weight on four wheels of a trailer, including the vehicle body and its load, to 28,000 lb. These recommendations give us a definite starting point for the design of pavements and their substructures.

A Minimum Width of 20 Ft.

Although those who have given careful consideration to the probable development of highway transport believe that the economic and efficient development of this form of transportation will not necessitate, for many years, the utilization of motor trucks having a greater capacity than 7½ tons, nevertheless it is admitted that it may be desirable in isolated cases to transport over highways loads on four wheels in excess of the limit prescribed. The transportation of such weights, however, should be provided for by special legislation rather than be accepted as the fundamental basis for design.

This discussion will be limited to a consideration of pavements suitable for interstate and intrastate trunk highways which will be subjected to an intensive motor-truck traffic. The width of the pavement should first be given consideration. Roadways economically designed must provide for carrying the traffic on the paved roadway surface, and not rely upon shoulders to carry a part of the traffic or serve as turnouts. It has been demonstrated that the latter practice is neither economical from the standpoint of the maintenance of pavements and shoulders, nor efficient or safe from the standpoint of the traffic using the highway. In other words, we must provide for a minimum of two lines of commercial traffic, and it is obvious that an operator of a heavy motor truck will insist upon allowing a certain amount of leeway between the outside wheels of the truck and the edge of the pavement, since many operators have had unfortunate experiences with motor trucks being stalled in soft shoulders or ditched. Considering the factors of widths and speeds of passenger cars and motor trucks utilizing trunk highways, and that the laws of many states permit a maximum width of 8 ft. for motor trucks, taken in conjunction with the rapid increase in the volume of traffic on trunk highways, the conclusion is reached that 20 ft. for the width of the pavement surface on a trunk highway should be considered the minimum. There are highways where the normal traffic requires provision for two lines of vehicles, and the abnormal traffic, particularly on holidays, Saturday afternoons and Sundays, will render the adoption of 24 to 26 ft. justifiable. This is due primarily to the fact that provision should be made for vehicles standing at the side of the road while temporarily requiring repairs. While traveling on a highway in the vicinity of Detroit, on a Sunday during July, 18 vehicles parked at the side of the roadway, and under repair, were passed in 15 min. on a 5-mile section. If the transport survey indicated that the normal amount of traffic will require provision for more than two lines of vehicles, a greater width than 20 ft. must be adopted, the additional width depending upon the character of the traffic. It does not require much imagination to reach the conclusion that many interurban highways will be subjected during the next decade to traffic which will necessitate roadways sufficiently wide to accommodate at least four lines of vehicles, which would mean a width of from 38 to 48 ft.

Construction Materials

For the classes of trunk highways under consideration, the roadway wearing course should be composed of a brick, plain or reinforced cement-concrete, bituminous concrete, sheet asphalt, wood block or a stone block pavement supported by a reinforced concrete, plain cement-concrete, bituminous concrete or heavy stone foundation. The selection of the particular type will depend upon many local economic factors and the results of the transport survey.

The highways outside of our municipalities have had a changeable status in the last 30 years, and the reasons advanced for their improvement have been many and varied, but mostly sound. Fortunately there has been rapidly developing throughout the land a conviction that highways are merely a means to an end and that end is the economic and efficient transportation of passengers and commodities. It has also become self-evident that unimproved and improperly built highways constitute a positive barrier to the development of economic highway transport. In order that highway transport should take its proper place in our transportation system, the following fundamental guiding principle must be accepted generally: Highways should be designed, constructed and maintained so as to enable them to carry efficiently the motor vehicles required for the rapid development and economic utilization of highway transport.—A. H. Blanchard in *Michigan Manufacturer and Financial Record.*

The Relation of Recoverance to the Fatigue of Metals

By Robert G. Guthrie[1]

Illustrated with Photograph and Chart

RECOVERANCE is a name representing a property which is inherent in all matter. The measurement of recoverance is made possible by the use of a testing machine called a Modulimeter, which is shown in Fig. 1. Extensive research on recoverance has been carried on at the laboratories which I represent, with a view to relating the recoverance values of various materials with the fatigue, wear, and durability values of these materials so that the adaptability and quality of any material for any specific purpose can be determined in simple understandable terms and by simple quick tests.

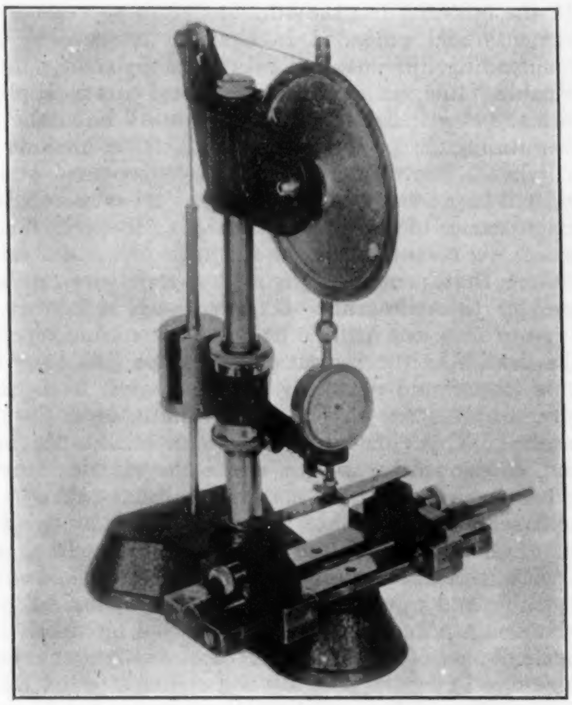


Fig. 1—An Instrument Designed to Test the Recoverance of Various Materials

The general definition of recoverance is stated as the capacity of a material to return *immediately* the energy that has been imparted to it by any external force. In other words, when the molecules of a material are forced by compression, tension or bending, from their relative normal position, the force immediately exerted by these molecules after the disturbing force is removed, in their return toward their normal position, is the recoverance of the material.

The recoverance figures given represent a percentage, depending upon the areas beneath the loading and unloading curves. These figures are, in reality, manifestations of the rate of recoverance, which is the all-important factor regarding fatigue. Because no mechanism is available that is capable of recording a recoverance curve, or the rate of recoverance, following the instantaneous removal of the total load, the plotting of a recoverance curve under a series of loads is necessitated. These curves, however, will be the same whether they are the result of the application of one load and its removal, or the result of this same amount of load applied in several increments and removed in successive decrements.

In a curve plotted automatically, covering the action of the material under a cycle of stress or repetitions of such cycles, the unloading line will diverge from the loading line in exactly the same way as one plotted under load. But, in plotting the curves under load, the complete cycle of loading and unloading is stopped during its course at definite points represented by the weight of each increment, and the deflections are noted. After this material has been loaded to any predetermined number of increments within its elastic limit and any of these increments have been removed, a point is reached which does not coincide with the corresponding point on the loading line. A loss then is represented by the divergence of the unloading from the loading line and, as long as this particular load remains upon the material, this distance will represent a total loss in strength to the material. If, however, the total load is removed at one time, similar

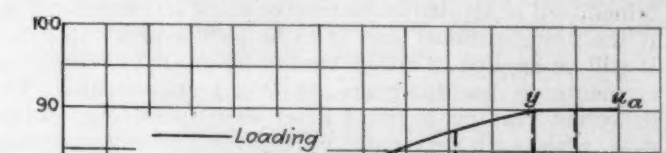


Fig. 2—Chart Showing the Recoverance of a Specimen That Has Been Subjected to Repeated Loads

[1] A. S. A. E.—Director of tests, Widney Test Laboratories, Chicago.

to the removal of the load during repetitions of stress, this curve will not stop at any of these points but will pass through them on its course back to the origin, *O*, in Fig. 2 on page 65. It then follows that, whatever the recoverance figure may be, the rate of recoverance will be directly proportional; i. e., if the curve of a material is plotted under load and a definite recoverance noted such as 80 per cent and another graph is plotted covering a different material, showing a recoverance figure of 70 per cent, it will then follow that the material showing the recoverance value of 70 per cent is lower by 10 per cent in recoverance, and also lower by 10 per cent in the *rate* of recoverance. In other words, all of the unloading lines in Fig. 2 show that the greater the distance to be traversed is, the greater the time is that will be required to traverse it, for the reason that they are curved lines. It then follows that the lower the percentage of recoverance is, the lower is the rate of recoverance; and that the higher the percentage of recoverance is, the higher is the rate.

The three distinct types of recoverance are produced by bending, tension, and compression. This paper deals only with recoverance produced by bending. The determination of recoverance on the modulimeter shown in Fig. 1 on page 65 is accomplished in the following manner. A metal sample 0.05 x 0.25 x 6 in. in dimensions is ground and polished and placed on knife-edges 4 in. apart. A gage graduated to 0.001 in. is directly connected to the plunger, which in turn is directly connected to the third knife-edge, equidistant from each of the supporting knife-edges. Equal increments of load of either 50 or 100 grams (1.76 or 3.52 oz.) each, depending upon the material, are placed on a platform carried by the plunger, which carries the third knife-edge. A predetermined load is applied in successive equal increments; i. e., if the predetermined load is to be 1000 grams (35.2 oz.) it will be applied in either twenty 50-gram (1.76-oz.) increments or ten 100-gram (3.52-oz.) increments. The deflection reading is noted after each increment. Likewise, when each decrement is removed the corresponding deflection is noted. The resultant then is a loading curve and an unloading curve. The ratio of area beneath the unloading curve to the total area under the loading curve gives the percentage of recoverance.

Fatigue

The recoverance of a material is a direct indicator of the ability of the material to withstand fatigue, but recoverance alone is not a conclusive measure of the susceptibility of a material to fatigue.

Referring to Fig. 2 on page 65, Curve *h*, the material is loaded to 20 increments, giving a certain deflection. This material is then unloaded and a slight loop is developed, although the material comes back to the point of beginning after the load has been removed. Subtracting the area of this loop from the total area underneath the increment curve gives the recoverance area. It will be noticed from this loop that the loading line and the unloading line do not coincide throughout their lengths. This is a manifestation of the fact that there is a loss when the material is gradually loaded in successive equal increments and unloaded in exactly the reverse order. The unloading line does not return to the same points on the loading line, although, if the total stress applied is within the elastic limit, the last point will be at the point of beginning, as previously stated. It is obvious then that, when a material is subjected to repeated stresses, there will be as many of these loops formed as there are complete cycles of stress. Inasmuch as the area bounded by a loop represents a loss in strength to the material, it is obvious that, providing the rate of repetitions of stress is greater than the rate of recoverance, a certain percentage of this loop will be held over from one repetition to the next. As the repetitions continue, the magnitude of this loop would naturally increase much as is shown in Fig. 2 by Curves *g*, *f*, *e*, *d*, *c*, *b* and *a*, until Curve co^1 is reached. This curve would not come back to the origin *o*, and, consequently, at this curve the elastic limit will have been reached and the material will have taken a permanent set. The loss then will not only be by the divergence of the unloading line from the loading line, which loss, were it in any curve such as Curves *d* or *e*, would be recoverable and would depend on a time factor, but there will be also a permanent loss represented by the distance oo^1, a small part of which may be recoverable over a period of time due to recoverance beyond the elastic limit. Provided these repetitions of stress were continued, the point

Table 1—Test of Standard Samples on Type X Machine, as Listed[2]

Series No.	Sample Material	Number of Increments	Recoverance Values, per cent						Stiffness		
			Test 1	Test 2	Test 3	Range	Average	After 3-hr. Rest	Deflection in 0.001 in.		Average, per cent
									Test 1	Test 2	
1	Cast Iron, No. 1	5	89.0	92.0	84.5	7.5	88.5	93.2	0.056	0.0505	37.5
2	Cast Iron, No. 2	5	93.6	95.0	97.4	3.8	95.3	93.5	0.044	0.0420	46.5
3	Cast Iron, No. 3	5	93.6	94.0	94.0	0.4	93.8	91.0	0.058	0.0635	32.8
4	Steel, No. 1	10	100.0	100.0	....	0.0	100.0	100.0	0.020	0.0200	100.0
5	Pure Swedish Bar Iron, No. 1	10	98.0	99.2	99.4	1.4	98.8	94.0	0.025	......	80.0
6	Cast Brass, No. 1	8	98.5	98.4	98.6	0.2	98.5	97.9	0.051	0.0500	39.6
7	Cast Brass, No. 2	8	97.9	98.4	98.9	1.0	98.4	96.9	0.056	......	35.7
8	Rolled Brass, No. 1	10	99.5	99.8	99.7	0.3	99.6	96.8	0.033	0.0330	60.6
9	Rolled Brass, No. 2	10	99.6	99.8	99.8	0.2	99.7	99.4	0.035	0.0350	57.1
10	Cast Aluminum, No. 1	5	98.5	99.1	99.6	1.1	99.0	98.4	0.084	......	23.9
11	Cast Aluminum, No. 2	5	99.6	99.1	99.1	0.5	99.2	....	0.064	......	31.2
12	Rolled Aluminum, No. 1	5	100.0	99.3	99.3	0.7	99.5	99.4	0.054	......	37.0
13	Rolled Aluminum, No. 2	6	98.4	98.8	99.5	1.1	98.9	93.0	0.049	......	40.8

[2]Dimensions of each sample, 0.05x0.25x4.875 in.; knife-edges at 4-in. span; weight of each increment, 3.8 oz.; all stiffness tests made under a five-increment load.

TABLE 2—TESTS OF STANDARD STEEL SAMPLES ON TYPE X MACHINE

Series No.	Sample Number and Condition: As Is	Burned	Magnetized Side X	Badly Burned in Forge	Ground and Slightly Annealed	After Burning and Deformation	Distance Between Centers, in.	Number of Increments	Weight of Each Increment, oz.	Recoverance Values, per cent: Rest Test	Regular Tests: 1	2	3	4	Average of Regular Tests, per cent
1	No. 3	....	....	....	....	....	4	5	14.7	97.5	99.5	99.8	99.9	98.5	99
2	....	No. 3	....	....	....	....	4	5	14.7	90.3	96.2	95.5	96.2	....	95
3	No. 4	....	....	....	....	....	4	5	14.7	100.0	100.0	100.0	100.0	....	100
4	....	....	No. 4	....	....	....	4	5	14.7	97.4	99.4	100.0	100.0	....	99
5	....	....	....	No. 5	....	....	4	8	3.5	92.0	96.3	94.8	96.5	....	95
6	No. 6	....	....	....	....	....	4	5	14.7	90.8	98.6	99.4	99.0	....	99
7	....	....	....	....	No. 6	....	4	5	14.7	.....	100.0	99.9	.....	....	99
8	....	....	....	....	....	No. 6	4	5	14.7	97.8	98.9	98.4	98.5	....	98

a would finally be reached, at which point the decrement line would cease to exist and this point would be the ultimate failure of the material or the fatigue ultimate. It must be remembered that Fig. 2 does not show all of the cycles of stress with their percentages of recoverance held over to the next time, but merely the succession of hysteresis loops to illustrate the theory of the foregoing. These curves were not plotted from an actual test on one material, but were compiled from numerous tests on various metal bars.

The definition of fatigue as given in Merriman's Mechanics of Materials is "the loss of molecular strength under stress often repeated." The recoverance mentioned in this paper is the result of stress within the elastic limit. Fatigue ultimate is the point at which failure occurs when a material has been subjected to oft-repeated stresses within its elastic limit. The direct factors in fatigue are the number, frequency and magnitude of stresses. It follows then that any material will develop fatigue and ultimately fail when the rate of repetitions of stress of any magnitude, within the elastic limit, is greater than the rate of recoverance. Conversely, there will be no fatigue when the rate of repetitions of stress of any magnitude, within the elastic limit, is less than the rate of recoverance. There is, however, a recoverance beyond the elastic limit, but no explanation of that will be given in this paper.

Where a difference in recoverance exists between two metals either similar or dissimilar, amounting to less than 1 per cent, it can be neglected and the metals characterized as having the same recoverance. As there should be a comparable difference in the recoverance of two metals if they are to be described as metals having different recoverance values, a difference of 1 per cent is established as a comparable recoverance difference in metals; that is, any metals not having a difference, one from the other, greater than 1 per cent will be classified as having the same recoverance. As shown in Table 1, Series 4, steel has an average recoverance of 100 per cent, whereas in Series 5 the average recoverance of pure Swedish bar iron is 98.8 per cent. The difference then is 1.2 per cent. It is thus obvious that these two metals have different recoverance values.

Referring to Table 2, Series 3 and 4, the tests on these samples show 100 per cent recoverance in the former and 99.4 per cent in the latter, the difference being 0.6 per cent. Consequently this metal was practically the same before it was treated as afterward.

Another Theory of Recoverance

A further theory regarding recoverance as applied to metals and theories regarding the reasons for recoverance can be advanced, although it is not expected that these theories will be accepted first-hand as absolute facts. But they are the natural conclusions to be inferred from data at hand.

The recoverance of a metal is governed by its chemical and physical homogeneity, and to a certain extent by its fineness of structure. In other words, if it were possible to obtain a metal of a solid solution and approaching a non-crystalline stage, it would follow that this material would have an extremely high recoverance and a high

TABLE 3—TESTS OF STANDARD STEEL SAMPLES ON TYPE X MACHINE[3]

Series No.	Sample Number and Condition: As Is	Normalized	Quenched	Dimensions, in.	Distance Between Centers, in.	Number of Increments	Weight of Each Increment, oz.	Recoverance Values, per cent: Test No. 1	Test No. 2	Test No. 3	Test No. 4	Percentage: Maximum	Minimum	Range	Average Recoverance, per cent
1	No. 1	....	....	0.05x0.25x4.875	2	5	14.7	100.0	100.0	98.0	....	100.0	98.0	2.0	99.3
2	No. 1	....	....	0.05x0.25x4.875	3	5	14.7	97.0	100.0	97.6	....	100.0	97.0	3.0	98.2
3	No. 1	....	....	0.05x0.25x4.875	4	5	14.7	99.1	96.0	98.5	....	99.1	96.0	3.0	97.8
4	....	No. 2	....	0.05x0.25x4.875	4	10	3.8	99.0	98.2	97.7	....	99.0	97.7	1.3	98.3
5	....	No. 2	....	0.05x0.25x4.875	4	5	14.7	97.9	98.7	99.0	99.0	99.0	97.9	1.1	98.6
6	....	....	No. 2	0.05x0.25x3.375	3	5	14.7	96.3	96.4	92.0	....	96.4	92.0	4.4	94.9

[3]All tests made with knife-edges.

fatigue value. Metals have been found averaging 100 per cent recoverance on the instrument mentioned, but 100 per cent recoverance absolute is not possessed by any material. This 100 per cent recoverance figure is obtained on an instrument which is not mechanically perfect. If it were possible to measure the recoverance of any metal on an instrument of the nature of the ultra-microscope and capable of infinitely finer work, it would be found that this material would not have a 100 per cent recoverance.

The statements regarding chemical and physical homogeneity and fineness of structure are exemplified in Table 1 on page 66. Steel sample No. 1, Series 4, which was in the sorbitic condition and showed every evidence of an excellent structure, tested 100 per cent recoverance. The obvious opposite of this material is a grey cast iron shown in Series 1, 2 and 3. These were three samples cut from the same bar. Comparing the average of their three recoverance averages with the average recoverance of the steel, the difference in 7.5 per cent. Further, the range of the three tests of cast iron No. 2, Series 2, is 3.8 per cent; whereas, in Series 3, cast iron No. 3 has a range of only 0.4 per cent, and in Series 1, cast iron No. 1 has a range of 7.5 per cent. It is obvious that this cast iron is extremely variable as regards recoverance and stiffness, which is no more than should be expected from a bar of this material.

Again referring to Table 1 on page 66, Series 10 and 11, the average recoverance of the aluminum is practically that of steel No. 1, Series 4. According to the theory, this would be expected. The aluminum was of good quality and, although not of the fineness of structure of the steel, they are somewhat related as regards their chemical and physical homogeneity. It will be noticed also that the stiffness values in the last column are only 1/4 and 1/3 those of steel No. 1, Series 4, notwithstanding the fact that the recoverance is practically the same. In the case of Series 5, the Swedish bar iron showed a recoverance comparably less than that of the steel, but approximately that of the aluminum; and, contrary to the comparison of the aluminum and the steel, which showed practically the same recoverance and a very low stiffness value, the Swedish iron has a very much higher stiffness value than any of the aluminums, but the recoverances are almost the same. In the case of the rolled brasses, Series 8 and 9, the recoverance is practically the same, as is their stiffness. The recoverance of the cast brasses in Series 6 and 7 is almost the same, as is their stiffness, but the stiffness of the cast brass in Series 7 is only about one-half that of the stiffness of the rolled brass in Series 8; the difference of their recoverances is, however, only 0.2 per cent over the limit set as a comparable difference.

The metals tabulated in Table 1 on page 66, have, as a whole, practically nothing in common as regards their so-called physical properties, with the possible exception of their structure as revealed under the microscope. It is meant by this that the physical properties of a presumably pure cast aluminum, Table 1, Series 11, and of a sorbitic steel, Series 4, are exceptionally far apart as regards their tensile strengths, elastic limits, elongations, reductions of area and the like, but that the aluminum as an elemental metal is approaching the state of chemical homogeneity, and that the steel in Series 4 is approaching the same state as a solid solution. Although their structures are somewhat different physically, it is evident that the further these metals get away from the mechanical mixture state, the higher will be their recoverance. This must not be construed to mean that aluminum can be used in the place of steel simply because their recoverances are the same or nearly so; but that, from any given number of bars of like material, the one highest in recoverance should be chosen for parts subjected to fatigue.

In the column showing 3-hr. rest tests, Table 1 on page 66, in all instances except Series 1, 4 and 12, the recoverance value of a rest test is considerably lower than that of a regular test. In this rest test, the material was tested after it had not been subjected to any external stresses for from 3 to 24 hr. The first test on each bar under these conditions was characterized as the rest test. The three regular tests followed as soon as possible. In many instances, as shown in Series 3, 5, 8 and 13, the rest test recoverance was much lower than in the lowest regular test

The hypothesis submitted regarding these rest tests is that when the material is at rest the molecules possess potential energy but, due to this state of rest, it is not necessary for these molecules to change this energy from the potential to the kinetic state. In other words, there is no greater amount of energy possessed by the molecules during the regular tests, or after they have been disturbed, than before; but there is a greater outward manifestation of the energy that is inherent in the molecules, due to the excitation by external force of their intra-atomic and intra-molecular activity. If this line of reasoning be carried still further, it can be said that a super-excitation of this intra-activity is produced which increases in magnitude and intensity with the increase of external stress until a point is reached where this internal strain or intra-activity is so intense that the molecules disrupt themselves. This causes an outward manifestation either across or along the planes of the crystals and still more apparent manifestations of probably a microscopic nature inter or intra-granular and, finally, a complete failure of the material under stress.

It is sometimes noticed that the path of a fissure may be either intra or inter-crystalline. This is evidently due to (*a*) what might be characterized as a series of weak or damaged crystals, an explanation of the existence of which will not be attempted in this paper; or (*b*), according to the present train of thought, highly localized intra-activity which in turn will follow as a natural consequence from the aforementioned weak crystals. The unit intensity or localization of this super intra-activity is evidently made possible by the original set of weak crystals.

The curve mentioned in the following paragraphs and shown in Fig. 2 on page 65, Curve *c*, which can be called for convenience one of stress-strain equilibrium, would start to fall rapidly at the point where the strain or intra-activity begins to be disproportional to the external stress or, in other words, where the rate of intra-activity begins to be greater than the rate of recoverance, which would be its elastic limit. This molecular power must be very great, because considerable work must be performed upon a material before it will ultimately fail as it does in a fatigue test. If a curve of this internal molecular resisting force could be plotted, it obviously would start very slightly below its peak, rise abruptly from this point to the peak and continue in practically a straight line, very slightly dropping toward fatigue ultimate for an infinite distance. The measure of the fall and length of this peak line would be determined by the rate of repetitions of stress, regardless of their individual magnitude, and the magnitude, provided it were great enough regardless of the rate of repetition. It should be possible under ideal conditions for a point of equilibrium to be established wherein the magnitude and rate of repetitions of stress would be exactly equal to the rate of recoverance. Then this line, other things being equal, would continue as an absolutely straight line to infinity.

Scientific Work of the Government[1]

By E. B. Rosa[2]

THE Federal Government, having emerged from participation in the world war, finds itself with a large debt and heavy annual charges caused by the war. These, together with the current cost of the Army and the Navy, amount for the present fiscal year to 92.8 per cent of the total budget. The cost of public works and the necessary administrative cost of the Federal Government amount to 6.2 per cent of the total. There remains 1 per cent for a large number of governmental activities classed as research, educational and developmental. The question arises whether in the interest of economy and efficiency the 1 per cent shall be decreased; or, because this work is constructive and of great economic value, whether it shall be increased and possibly doubled.

The Government should be constructive and helpful to the people and to business wherever possible. It should carry on scientific research, promote education, develop the industries, assist in improving commercial and industrial methods and furnish technical information to manufacturers and others, as well as develop agriculture and the public domain. Such service by the Government tends to establish good relations with business, elevate business methods, increase efficiency and educate the public. The many services thus rendered cost very little in the aggregate as compared with the total expense of the Government. One per cent of the total expenses of the Government spent in this constructive way seems a very small proportion in view of the wide range and the economic value of such work.

A part of this 1 per cent is incurred in behalf of the Government itself, to enable it to purchase its supplies intelligently and to do business in a businesslike way. Without this research and testing work the Government would waste more in buying than it would save by eliminating the research and testing. Making purchases without full technical information is embarrassing to public officials and unsatisfactory to business; whereas by always using intelligently-drawn specifications and making adequate tests, the Government can save money, elevate its own service and improve business methods. Much, but not enough of this kind of work is now done. It is the duty of the Government to set a good example of efficient and intelligent methods and fair dealing; neither accepting goods below the specified quality nor demanding more than is specified. The Government would spend less for its purchases if it spent more in standardizing the products purchased and in testing deliveries systematically.

Apart from the service the Government can render its citizens and the benefit to the State resulting from scientific, educational and developmental work, and apart from the benefit to the Government of having the results of such work in constructing buildings and other public works, and in carrying on its business, this kind of work develops wealth. Economizing in the use of raw materials, using cheaper materials, reducing waste, developing the public domain. increasing manufacturing efficiency and reducing distribution costs, all tend to create wealth and to make it easier for the Government to raise needed revenue.

[1]From a lecture before the Washington Academy of Sciences.
[2]Chief physicist, Bureau of Standards, Washington.

To check rising prices and, if possible, bring down prices, it will be necessary to increase production. To do this it is necessary to reduce waste and increase efficiency. This requires greater intelligence and fuller knowledge, and calls for education, the results of scientific investigation and of intelligent and extensive industrial research. The Government could not and should not do it all. But neither should it refuse to do its part, and its part often is to take the lead in a constructive and statesmanlike way. It is stupid and blind to think that because taxes are heavy we cannot afford to do things intelligently. Intelligent research by the Government stimulates production, increases wealth and pays for itself many-fold. It is as productive and profitable in peace as in war.

The development of our intellectual, moral and material resources, is the best preparation for war. Food and manufacturing facilities, adequate supplies of raw materials and transportation systems, scientific attainments, the equipment and trained personnel available for military research, together with an intelligent citizenry and a just cause, are the best preparation for war. A standing army and fleets of battleships are necessary but not a sufficient preparation. A government that pays much attention to education and research and industrial developmental work is making the best preparation for possible wars of the future. This fortunately produces good results if war never comes. Increasing the power and prestige of the nation tends to prevent war. We should strive for a higher and truer efficiency in the Government, in labor and in business.

ENGINEERING MUSEUM

WHEN will the great Museum of Engineering be started in America? For anyone who knows the importance of engineering it is a great pleasure to see that in the National Museum in Washington the famous Stevens marine engines and many other masterpieces of engineering are accorded equal prominence with other exhibits. What Paris can boast of in its Conservatoire des Arts et Métiers, London in its Kensington Museum, and Munich in its German Museum will surely in no distant future be emulated by a country which has risen into prominence with steamships and railroads and through the achievements of engineers who are famous throughout the civilized world at the present time.

The science of engineering is not confined to the boundaries of any one country, and as in Munich the masterpieces of the different nationalities are placed peacefully side by side, so the future great American Engineering Museum will no doubt bear testimony to the fellowship of all engineering and scientific research workers.—C. Matschoss in *Engineering News-Record.*

RAILROAD VALUATION

THE Interstate Commerce Commission began to appraise the railroads in 1914, and is about half done with the job. It estimated the value of the roads to be $17,525.000,000 on June 30, 1916. In the recent rate decision the Commission fixed the value of the railroads at $18,900,000,000, which is more than its estimate of 1916, and yet is $1,716,000,000 less than the total presented by the roads themselves.—J. C. Marquis.

SHALE OIL

IN 1913 the Bureau of Mines began to investigate the oil shale deposits in Colorado, Utah, Nevada, Wyoming, Montana and California, primarily to lay the predicate for segregation of land and secondarily to ascertain the extent, character and commercial value of the deposits. Dean Winchester conducted the field work of testing the shales and arriving at approximate values and the location of the best deposits. When enough had been known to indicate the major deposits, two areas in Colorado and Utah, uniting practically as one, were withdrawn as naval reserves for oil, about 86,000 acres altogether. Mr. Winchester's investigations and tests were incorporated in Government reports. Over 100 companies were organized by residents of the states in which shales are found, beginning three or four years ago. Some of the companies began preparations to put up demonstration plants in Salt Lake and Denver, and finally to move some material to the locations of their leased or fee acreage, notably near De Beque, Col.

Efforts were made to learn about the shale oil plants that had been operating in Scotland 50 years, and the Scotch processes were generally accepted as the basis for further experimentation and modified demonstration. For two or three years there was considerable activity. There is not a plant in the United States that is turning out shale oil, either crude or by-products, and every one that is active is experimenting. The processes that are being worked on for successful adoption by the trade are known as the Galloupe, the Genet, the Jenson, the Sundberg-Lichliter-Winter, the O'Rourke, the Stallman, the Catlin, the Day and perhaps two or three others. The Henderson or Scotch and the DeBry or French principles of retorting form the base of all experiments, probably because they have been successfully employed in commercial plants. This is especially true of the Henderson processes used in Scotland. So far as it is known, only six plants are now active; one at Elko, Nev.; one at Dillon, Mont.; one at Salt Lake and one at Dragon, Utah, and two at DeBeque, Col. There is one plant at Elko, two at Salt Lake, one at Watson, Utah, and several at DeBeque district that are inactive.

Shale oil is contained in solid sedimentary substances deposited through still water on the bed of the body of water and formed from marine life, organic and inorganic. The ore must be mined, crushed and run into a retort, where it is superheated until the gases or vapors are thrown off and conveyed through pipes to a condenser, where it becomes a black, heavy and viscous fluid of rank odor. As mere crude oil, thus run off, it does not appear to be as valuable as crude petroleum. Treated in a standard petroleum refinery the results are problematical. If gasoline, naphtha, kerosene, lubricating oil and paraffin wax are desired for commercial profit, superficially it seems that petroleum is more amenable and valuable than shale crude oil. Analyzed by ordinary scales, petroleum appears preferable to shale oil.

The chemists and engineers who have delved deepest into shale and its derivatives are fairly agreed that direct methods of precipitating and stabilizing its ingredients, as with crude oil petroleum do not yield satisfactory results. Oil shale is complex and reflex, and must be treated synthetically, if experiments to date indicate anything. Experimentation has progressed far enough to determine beyond doubt that oil shales are like petroleum, gold, copper, or any other natural product, in that they vary in quality and content quantity almost as frequently and unexpectedly as petroleum oil sands. Some shale will yield only a gallon of crude oil, some will yield 10 gal., some will yield 20 gal. and up to 30 or 40 gal. per ton. The Bureau of Mines Experiment Station at Salt Lake has found none passing through its retorts that yielded more than 65 gal. per ton, and very little that ran that high. A barrel of 42 gal. per ton, with all the data at hand, is a maximum average that probably will not stand up in commercial operation the country over.

Some shales that produce 42 gal. of oil per ton, when that crude oil is very low grade, would be worth no more than shale producing 5 gal. of high-grade oil. Shale oil varies in gravity and distillate content as widely as crude petroleum differs in gravity and content, or as natural gas varies in gasoline content. Crude shale oil shows a Baumé gravity rarely exceeding 23 deg., indicating a low place in the light distillate scale. No one expects to secure much gasoline or other valuable distillates from 20-gravity crude petroleum, not even ordinarily very much true lubricant, because the manner of its formation and deposition in the lower scales of liquid hydrocarbons was unfavorable.

After a fairly comprehensive investigation of the fields and plant equipment, I am inclined to believe that a commercial industry of importance and reasonable profit to those who engage in it intelligently and efficiently will be established. This result will come not because oil shale must replace and displace petroleum or because it is better and more valuable than petroleum, but because it provides an avenue for capital to be profitably employed.

It appears that the Kentucky shales of the oil-bearing variety are fundamentally the same as Rocky Mountain oil shales, all being of perfect sedimentary deposition, which means at the bottom of water bodies, and of marine origin, geologically. Trenton rock strata in Ohio, Indiana, Kentucky and Illinois are of that geologic period and origin, just as Rocky Mountain shales, now on top of everything, were at one time the bottom, the sedimentary floor, catching the drippings, good, bad and indifferent, heavily saturated with organic and inorganic marine life, largely fish and amphibious and aquatic animals and birds, saturated with salt water, gypsum, sulphur and oxidations from other minerals. Fundamentally, therefore, a reasonable conjecture would be that any mixture formed in such circumstances is not as clean and specifically fixed in its predominating elements as petroleum from washed and crystallized sands and limes. After many years of testing it is known fairly well that petroleum produced from soft and muddy formations along the coast and of heavy gravity cannot be made to yield quantitative and qualitative fractions that exist in the hard, crystallized sand strata of the higher interior regions.

It was almost half a century after petroleum became a commercial industry before gasoline became a dominant factor. Likewise it is likely to be some years before oil shale comes to a clear recognition of its commercial place and value. If it should be classified as a low-grade ore useful in low-priced industrial processes, it inevitably cannot maintain an exaggerated claim to a place among the aristocracy of hydrocarbons.—H. L. Wood, in *National Petroleum News.*

GRAND CENTRAL TERMINAL

THE Grand Central terminal in New York City is a remarkable civic development for which there is no precedent. Although its traffic capacity has by no means been reached and the development of the whole is still incomplete, the terminal is used daily by 50,000 to 100,000 people besides 111,040 arriving and leaving on trains. One of the surprises to the management is the result of actual counts of people who do not use trains but still pass in and out of the terminal. Of the daily train passenger traffic about 65,480 are suburbanites, and this portion of the traffic is steadily increasing. The number of passengers in and out of the station on trains in 1903, at the beginning of reconstruction, was 16,135,667, or 44,200 per day, as compared with 32,338,053 in 1919, or 88,500 per day.—*Engineering News-Record.*

ACTIVITIES OF THE SECTIONS

Sections Calendar

BUFFALO
Jan. 18—The Use of Technical Motion Pictures in Engineering by T. R. Fessenden

CLEVELAND
Jan. 28

DAYTON
Jan. 18—Dinner and Organization Meeting Engineers Club 6 p. m. Technical Session 8 p. m.

INDIANA
Jan. 4—Maj. T. H. Bane

METROPOLITAN
Jan. 20—Service by Cyrus J. Rankin. Visit to large New York Service Station

MID-WEST
Jan. 7—Scientific Cushioning in Truck Design by Charles O. Guernsey.

MINNEAPOLIS
Jan. 5—Future Outlook for the Tractor
Feb. 2—Fuels
Mar. 2—Good Roads and Equipment
Apr. 6—Tractor Service and Repair Equipment

PENNSYLVANIA
Jan. 18—Afternoon—Trip to Navy Yard
Evening—Story of Petroleum film

WASHINGTON
Jan. 7
Feb. 4

AT the last meeting of the Council the formation of the new Washington Section was approved upon the recommendation of the Sections Committee. Previous to this action the Washington members of the Society had held a meeting at the Cosmos Club which was attended by 35, notwithstanding the fact that the American Petroleum Institute gave a dinner and the Federated American Engineering Societies had a smoker on the same evening. Those who attended had the pleasure of hearing Capt. St. Clair Streett, who was in command of the Alaska Flying Squad, tell of the experiences of his party in their flight to Alaska and return. This flight, to which too little attention has been given, constituted perhaps a greater test of not only the dependability of the machines employed but also of the nerve of the operators than did even the transatlantic flights. Captain Streett's endorsement of the Liberty engine, with which his plane was equipped, was whole-hearted and sincere. His remarks should encourage very much those who believe in the destiny of American aircraft. Coker F. Clarkson, general manager of the Society, gave an informal talk on the origin, accomplishments and aims of the Society. A number of the members expressed the need of regular gatherings in Washington of those interested in the automotive field with the end in view of not only increasing their technical knowledge but also of meeting other men in the profession in a social way.

It is expected that the Section will in a large part constitute a connecting link in the research work in which the Society and various Government departments are particularly interested.

The election of the following temporary officers is a guarantee of the success of the Section:

Chairman, Dr. H. C. Dickinson
Vice-Chairman, Col. F. H. Pope
Secretary, Archibald Black
Treasurer, C. H. Young

Those desiring to join the Section may do so by communicating with the Secretary, Archibald Black, whose address is Evening Star Building, Washington. Meetings of the Section are scheduled to be held at the Cosmos Club on Jan. 7, Feb. 4, April 1, and May 6. Particulars as to subjects and speakers may be obtained from Secretary Black.

The Indiana Section turned out in goodly numbers on Dec. 1 for an informal dinner, after which a paper on high-speed engines of small piston displacement was presented by C. W. Van Ranst. The deplorable fatal accident suffered by Gaston Chevrolet prevented the attendance of his brother, Louis Chevrolet, who was a co-author with Mr. Van Ranst.

Due to pressure of business which requires his time, Chester S. Ricker has resigned the chairmanship of the Indiana Section. The Governing Committee has elected Lon R. Smith to fill the vacancy for the unexpired term.

The Annual Meeting at New York City during Automobile Show Week will draw perhaps a larger attendance than ever before. Although the automotive industry in common with all others is at present in a period of readjustment, the value of the engineer was never more felt. There never was a time when the services of the engineer were more needed. Cars and automotive apparatus in general of good design which are economically manufactured have a great advantage in the world's markets. When it is realized that the engineer is responsible for both design and production, his importance in the present situation will be universally accepted. It is fitting therefore that the manufacturing companies now more than ever before insist upon the attendance of their engineers at the 1921 New York Automobile Show and the 1921 Annual Meeting of the Society.

The Cleveland Section will run at least two special cars to New York on Sunday, Jan. 9. These cars will leave Cleveland at 7.20 p. m. Those who desire to go with their local Section should write or telephone the Secretary of the Section, A. E. Jackman, 1900 Euclid Avenue. Other special cars will be run from Chicago and from Detroit. Details of arrangements may be had from L. S. Sheldrick, secretary of the Mid-West Section, 333 South Dearborn Street, Chicago, and from M. H. Cox, secretary of the Detroit Section, 1361 Book Building, Detroit.

All members of the Society in Dayton or vicinity are urged to attend a dinner at the Engineers Club in that city on Jan. 18, at six o'clock, at which the establishment of a Dayton Section will be discussed. Considerable interest in this project has already been shown by members in Dayton, and this meeting should bring together all of those who believe in the need of a Section there. It is believed that such an organization, working in conjunction with the highly successful Engineers Club, can do much toward disseminating engineering knowledge and the results of the research work conducted in Dayton territory. After the consideration of the Section organization, the members will listen to a technical paper for which arrangements are being made by the committee.

The Boston Section which was organized in September with 27 members, now has over 50 on its rolls. This confirms the fact that the organization was fully warranted. The Section met on Nov. 19 at the Engineers Club for dinner and later listened to a paper by E. Southworth Church on The Car the User Wants. Mr. Church treated the subject from his experience in automobile sales work. He feels that the day of the heavy uneconomical car is past and that the light machine of good design will more thoroughly meet the public demand.

The discussion of the paper indicated that very many people agree with the opinion expressed by the author, although the contention was made that the engineer must frequently modify his design in view of price limitations and production requirements. Most of the discussion centered around body and chassis construction and spring suspension.

Benjamin F. Bailey, professor of electrical engineering at the University of Michigan, addressed the Detroit Section on the evening of Dec. 17 on Starting, Lighting and Ignition. A buffet supper was served before the reading of Professor Bailey's paper. Moving pictures on the subject were a part of the evening's program.

On Dec. 1 Archibald R. Crawford talked to the members of the Minneapolis Section on the Present Status of the Tractor Industry, considering the subject from the standpoint of the manufacturer, the dealer and the user. He pointed out the necessity of educating the dealer and through him the farmer in tractor economics, and stated that the law of the survival of the fittest is now being applied to tractor manufacturers. On the same evening C. S. Moody gave a paper on the treatment of plain carbon and alloy steels for use in tractor construction.

The January meeting of the Mid-West Section will be held on the 7th. Charles O. Guernsey, chief engineer, Service Motor Truck Co., will speak on Scientific Cushioning in Truck Design.

The Metropolitan and Pennsylvania Sections held a joint meeting on the afternoon of Dec. 14 prior to the Motor Boat Meeting of the Society. The members of the Pennsylvania Section were met upon the arrival of their train from Philadelphia by a committee of Metropolitan Section members and had luncheon, after which they were taken by special motor buses to the plant of the Consolidated Shipbuilding Corporation where motor boats and engines of all sizes in various stages of construction were inspected. The members of both Sections then attended the Motor Boat Show.

As a sequel to the paper presented by Lieut.-Com. H. Gibson, U. S. N., at the Motor Boat Meeting, the Pennsylvania Section will conduct a trip on the afternoon of Tuesday, Jan. 18, to the League Island Navy Yard, where the big German Diesel engine will be under observation. The party will leave the Engineers' Club at 3:30. Members of the Section will later dine at the Engineers' Club and hold a discussion on Diesel engines. An excellent four-reel film on "The Story of Petroleum" will be shown. This film follows the liquid fuel from its source to the ultimate consumer.

OBITUARY

JULIUS A. PERKINS, mechanical director of the Universal Roller Bearing Co., New York City, died Dec. 7, 1920, at the age of 72 years. He was born at Hudson, Mich., in November, 1848. During his youth he worked about five years in a wagon shop at Sublett, Ill.; his further training for about 16 years was in his own machine shop and in various other shops in Omaha, Neb., Chicago, and Bremen and Berlin, Germany. His work included drafting, designing, making and superintending the manufacture of special machine and small tools and roller and ball bearings and parts. His engineering experience since the completion of his training included about 15 years inspecting manufacturing plants for fire insurance companies and in adjusting fire losses on manufacturing plants and machinery and over 16 years in designing, directing and superintending the drafting and making of special machinery and parts, and in the development of the Moffett and Perkins roller and ball bearings. He was a member of the American Society of Mechanical Engineers. He was elected to Member grade in the Society of Automotive Engineers, March 5, 1908.

WILLIAM T. R. PRICE, chief engineer of the oil engineering department of the Ingersoll-Rand Co., Phillipsburg, N. J., died at his home in Easton, Pa., Nov. 7, 1920, at the age of 35 years. He was born May 1, 1885, in Chester County, Pa., and, following his preliminary education, completed a three-year course in steam and machine design at Pratt Institute, Brooklyn, N. Y., in 1906. From 1908 to 1910, he lectured and gave instruction in general automobile construction, operation and repair, at the New York School for Automobile Engineers. Mr. Price was superintendent of motor transportation for the Government in the Philippine Islands from 1911 to 1913. He operated a motor transport system of 52 motor trucks over the difficult Benguet mountain road, for the Bureau of Public Works, and in 1913 supervised the transportation of 23,000 passengers and 7000 tons of freight without any loss of life or a serious accident. In the years 1914 and 1915 he was principal and part owner of the Toronto Automobile School, Toronto, Canada.

His service for the United States Government from 1917 to 1919 was distinctive. As sergeant, he had charge of all motor transportation at Madison Barracks, N. Y., and as second lieutenant rendered a similar service at Camp Meade, Md. As captain and major, he was in command of the 304th Divisional Supply Train at Camp Meade and served for 10 months in France with the 79th Division. He was motor-transport officer during part of the operations of this division and acting commander of trains during the severest American offensive in the Meuse-Argonne. As commander of the 304th Supply Train he was in charge of 500 men and 150 motor trucks. This supply train was eminently successful in all of its operations. Major Price was cited for meritorious services in organizing motor transportation and for expert technical and mechanical services in connection therewith, by the commanding general of the American Expeditionary Force.

Following his Army service and until his demise, he was engineer for the International Motor Co., New York City, president of the Price Engine Corporation, New York City, second vice-president of the Rathbun Engineering Co., Toledo, Ohio, and chief engineer of the oil engineering department of the Ingersoll-Rand Co. He was elected to Member grade in the Society June 21, 1920.

BENJAMIN F. TOBIN, organizer and chairman of the board of directors of the Continental Motors Corporation, Detroit, died suddenly at his home in that city Nov. 23, 1920, at the age of 55 years. He was born at Chicago Nov. 29, 1865.

Mr. Tobin established the Continental Motors Corporation and was connected with its activities in various capacities during the past 16 years, being president and general manager for several years prior to his death. He was made chairman of the board of directors in January, 1920.

He was widely known in social and fraternal organizations and was elected to Associate Member grade in the Society Nov. 20, 1918.

Applicants *Qualified*

The following applicants have qualified for admission to the Society between Nov. 10 and Dec. 10, 1920. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member; (E S) Enrolled Student.

ALCURE, FIRST-LIEUT. JOHN F. (J) chief inspector, Camp Holabird, *Baltimore.*

BAILLY, LOUIS (M) chief engineer, Ohio Municipal Equipment Co., *Columbus, Ohio,* (mail) 119 West First Avenue.

BARNES, NEWELL H. (A) cost accountant, Cushman Motor Works, *Lincoln, Neb.,* (mail) 1848 Prospect Street.

BATES, MORTIMER F. (M) assistant engineer, Sperry Gyroscope Co., *Brooklyn, N. Y.,* (mail) 1544 48th Street.

BENJAMIN B. R. (M) superintendent of experiments, McCormick Works, International Harvester Co., Chicago, (mail) 329 North East Avenue, *Oak Park, Ill.*

BESELIN, H. J. (M) production engineer, O. E. Szekely Co., Moline, Ill., (mail) 845 17th Street, *Rock Island, Ill.*

BIRD, D. A. (A) Cleveland Radiator Co., *Euclid, Ohio.*

BRADLEY, C. S. (A) district sales manager, Jones & Laughlin Steel Co., Pittsburgh, (mail) 1019 White Building, *Buffalo.*

BRAND, PAUL H. (M) chief engineer, Little Giant Co., Mankato, Minn., mail 608 Marion Street, *Oak Park, Ill.*

BREER, CARL (M) assistant chief engineer, Willys Corporation, *Elizabeth, N. J.*

BRENNER, RAYMOND E. (M) chief engineer, Coupler-Gear Freight-Wheel Co., *Grand Rapids, Mich.*

BRIGGS, JOHN W. (M) general superintendent, Cushman Motor Works, *Lincoln, Neb.*

BROWN, FRANK L. (M) general superintendent, White Motor Co., *Cleveland,* (mail) 1014 Lakeview Road.

BROWN, GEORGE M. (M) engineer, Liberty Devices Co., Boston, (mail) 853 Seventh Avenue, *New York City.*

BROWNYER, NELSON R. (J) draftsman, Bollstrom Motors, Inc., *St. Louis, Mich.*

BUDERUS, W. H. (M) automotive engineer, Sun Co., *Detroit,* (mail) 2476 Hazelwood Avenue.

BUTLER, E. J. (J) assistant engineer, Freeman Motor Co., Cleveland, (mail) 14315 Elm Avenue, *East Cleveland, Ohio.*

CARPENTER, MAJOR W. T. (S M) Coast Artillery Corps, care of Holt Mfg. Co., *Stockton, Cal.*

CASE L. B. (M) chemist, General Motors Corporation, *Detroit,* (mail) 2261 Garland Avenue.

CHRISMAN, CARL R. (J) draftsman, Garford Motor Truck Co., *Lima, Ohio,* (mail) 411 West Elm Street.

CLARK, HERBERT (M) Hotel Newton, High Street, *Worcester, Mass.*

COAPMAN, J. (M) chief engineer, Russel Motor Axle Co., *Detroit,* (mail) 2015 Highland Avenue.

COLLINS, F. ALTON, JR., (A) manager, Auburn Ball Bearing Co., 29 Elizabeth Street, *Rochester, N. Y.*

COMEY, H. C. (A) factory manager, Texas Motor Car Association, *Fort Worth, Tex.*

CREAMER, JOHN F. (A) manufacturers representative, Firestone Steel Products Co., *Akron, Ohio.*

CRONSTEDT, VALDEMAR NISON (J) draftsman, engineering department, Commercial Truck Co., *Philadelphia.*

CUMMINS, CLESSIE LYLE (A) president and general manager, Cummins Engine Co., *Columbus, Ind.*

CURRIE, ARCHIBALD P. (M) chief draftsman, Dominion Steel Products Co., Ltd., *Brantford, Ont., Canada* (mail) 236 St. Paul's Avenue.

DEIMEL, ALBERT H. (A) experimental engineer, Chrobeltic Tool Co., *Michigan City, Ind.*

DEMORE, L. A. (M) chief engineer, Mercury Mfg. Co., Chicago, (mail) 619 North Park Avenue, *Oak Park, Ill.*

DERR, H. E. (M) assistant chief engineer, International Harvester Co., Chicago, (mail) 113 East Center Street, *Akron, Ohio.*

DIETZ, EDWARD H. (M) assistant chief draftsman, International Harvester Co., *Akron, Ohio* (mail) 680 Edgewood Avenue.

DOLLIN, EDGAR N. (M) general manager, Precision Castings Co., Inc., *Syracuse, N. Y.*

DURLAND, HARRY S. (E S) student, Pratt Institute, Brooklyn, N. Y. (mail) 63 Hinsdale Place, *Newark, N. J.*

DYKSTRA, JAMES (J) designer, Saxon Motor Corporation, *Detroit,* (mail) 3408 Townsend Avenue.

FENTON, DANIEL H. (A) head of tire testing department, Fisk Rubber Co., *Chicopee Falls, Mass.*

FRAME, C. C. (M) chief transportation engineer, Service Motor Truck Co., *Wabash, Ind.* (mail) 447 North Thorn Street.

FRANCE, EDWARD A. (A) district sales manager, Jones & Laughlin Steel Co., Rockefeller Building, *Cleveland.*

FURUBAYSHI, USABURO (F M) chief inspector, automobile department, Tokyo Gas & Electric Engineering Co., Ltd., *Omori-machi, near Tokyo, Japan.*

GARGIULO, SALVATORE (A) master mechanic, G. & O. Mfg. Co., *New Haven, Conn.* (mail) 61 Lyon Street.

GILMAN, NORMAN H. (M) general manager and chief engineer, Allison Experimental Co., *Indianapolis* (mail) Box 894.

GRILL, C. H. (J) chief draftsman, Foote Bros. Gear & Machine Co., *Chicago.*

HALL, H. K. (A) general manager, Cleveland Radiator Co., Bliss Road, *Euclid, Ohio.*

HARRINGTON, C. G. (M) chief draftsman, Gardner Motor Co., St. Louis (mail) 7278 Anna Avenue, *Maplewood, Mo.*

HAWKINS, P. E. (M) engineer, Ohio Motor Vehicle Co., *Cleveland,* (mail) 18 Groveland Club, 14617 Lake Shore Boulevard.

HEGENAUER, CHARLES J. (J) mechanical draftsman, Chevrolet Motor Co., New York City, (mail) 25 Nepera Place, *Hastings, N. Y.*

HELMS, JOHN R. (A) director of instruction, Petz Automotive School, Inc., Philadelphia, (mail) 44 Morton Avenue, *Morton, Pa.*

HENDRICKS, R. G. (A) manager, King Motor Car Co., *Detroit,* (mail) 85 West Hancock Avenue.

HENRY, JOHN J. (A) engineer, Bethlehem Motors Corporation, *Pottstown, Pa.* (mail) Y. M. C. A.

HOERLE, NEWTON SWANK (M) manager of engineering department, Continental Motors Corporation, *Muskegon, Mich.*

JOHNSON, HOWARD M. (A) manager rebuilt truck department, Mack International Motor Truck Corporation, 1628 East Seventh Street, *Los Angeles, Cal.*

JOSEPH, LAWRENCE E. (M) sales engineer, Snead & Co. Iron Works, Jersey City, N. J., (mail) 11204 Willowmere Avenue, *Cleveland.*

KLEIN, FREDERICK H. (A) draftsman, Nelson Blower & Furnace Co., South Boston, (mail) 304 Amory Street, *Jamaica Plain (30) Boston.*

KLINE, CHARLES E. (A) superintendent assembly, Hahn Motor Truck & Wagon Co., *Hamburg, Pa.* (mail) Box 67.

KOEHNE, IRA CHASE (M) chief engineer, Preferred Motor Car Co., *Indianapolis.*

LANGENHEIM, ALBERT H. (M) chief draftsman, Eaton Axle Co., *Cleveland.*

LEAKE, THOMAS C. (M) engineer, Bear Tractor Corporation of America, Bridgeport, Conn., (mail) Herald Square Hotel, 114 West 34th Street, *New York City.*

LEMON, ARTHUR (M) engineer, Excelsior Motor Mfg. & Supply Co., 3700 Cortland Street, *Chicago.*

MCCLAIN, HARRY O. (M) chief engineer and production manager, American Truck & Trailer Corporation, *Kankakee, Ill.,* (mail) 788 South Osborn Avenue.

MCCREERY, H. L. (M) chief engineer, Standard Welding Co., *Cleveland.*

MCGEADY, ROY (E S) student, College City of New York, (mail) 147 Sixth Avenue, New York City.

MCKEE, WILLIAM J. (A) vice-president, Osgood Bradley Car Co., *Worcester, Mass.*

MARTIN, WILBUR A. (M) design engineer in charge of layout work, Glenn L. Martin Co., *Cleveland,* (mail) 1845 Belmore Road.

MERANDA, WILLIAM O. (J) chief draftsman, Hoosier Auto Parts Co., *Muncie, Ind.*

MILLER, J. MACKENZIE (J) test engineer, McCook Field, Dayton, Ohio, (mail) 4146 Floral Avenue, *Norwood, Ohio.*

MILLER, WILLIAM O. (J) draftsman, Holt Mfg. Co., *Stockton, Cal.,* (mail) 1009 North Sutter Street.

MOODY, COL. LUCIAN B. (S M) chief of tank, tractor and trailer division, Ordnance Department, *Washington.*

MOORE, FEARON D. (A) technical field representative, General Motors Export Co., *New York City* (mail) Box 86, Station G.

MORAND, LESTER J. (J) mechanical engineer, Morand Cushion Wheel Co., *Chicago.*

NEAL, FRANKLIN G. (A) patent attorney, Fisk Rubber Co., *Chicopee Falls, Mass.*

NEWELL, FLOYD BELL (M) mechanical engineer, Bureau of Standards, *Washington,* (mail) 417 Randolph Street.

O'NEAL, E. P. (J) instructor, Okmulgee Vocational High School, *Okmulgee, Okla.*

PERIN, DONALD W. (A) president, Perin Automotive Engineering Co., 10 Scotia Street, *Boston.*

POLHEMUS, DONALD W. (J) draftsman, Class Journal Co., New York City, (mail) Glen-Byron Avenue, *Nyack, N. Y.*

PURVIS, JOHN W. (A) designing engineer, McCord Mfg. Co., *Detroit,* (mail) 280 West Ferry Avenue.

RAPIN, EDWARD A. (J) layout draftsman, Oakland Motor Car Co., Pontiac, Mich., (mail) 1129 North Webster Street, *Saginaw, Mich.*

REED, RODMAN S. (M) chief engineer, Brockway Motor Truck Co., *Cortland, N. Y.,* (mail) 33 West Court Street.

RODGER, DAVID WILLIAM (A) sales manager, Muzzy-Lyon Co., *Detroit.*

SAWYER, WILFRED D. (J) assistant engineer, Baker Steam Motor Car & Mfg. Co., *Pueblo, Col.,* (mail) 110 West 12th Street.

SCHLACHTER, DEAN H. (A) supervisor of motor mechanics school, Fort Crook, Neb., (mail) 2333 South 35th Avenue, *Omaha, Neb.*

SCHREIBER, KARL O. (A) assistant superintendent, International Harvester Co., *Springfield, Ohio.*

SCHULER, C. R. (M) engineer, truck and tractor division, Midwest Engine Co., *Indianapolis*, (mail) Haugh Hotel, 11 East Michigan Street.

SCHULTZ, J. A., JR. (A) assistant manager, Doehler Die-Casting Co., *Toledo, Ohio*, (mail) 1422 Goodale Avenue.

SEAVERNS, BYRON H. (M) designer, Service Motor Truck Co., *Wabash, Ind.*

SOHN, MILTON G. (J) mechanical draftsman, Holt Mfg. Co., Stockton, Cal., (mail) General Delivery, *Pittsburg, Cal.*

STERN, MARCUS (M) chief engineer, Doehler Die-Casting Co., *Toledo, Ohio*, (mail) 2342 Rosewood Avenue.

STOCKFLETH, BERGER (M) chief engineer, International Harvester Co., *Chicago*, (mail) 2422 Drake Avenue.

STONE, FRANK J. (A) branch manager, Electric Storage Battery Co., 718 Beacon Street, *Boston*.

STUDNICKA, JOSEPH (M) tool and machine designer, Dodge Bros., *Detroit*, (mail) 4454 Moore Place.

TAYLOR, EDWARD CURTIS (M) patent attorney, Fisk Rubber Co., *Chicopee Falls, Mass.*

TORRANCE, JAMES B. (M) assistant professor, University of Minnesota, St. Paul, Minn., (mail) 3744 Portland Avenue, *Minneapolis, Minn.*

WALLACE, WILLIAM M. (M) chief draftsman, bureau of construction and repair, Navy Department, *Washington*.

WALTER, C. G. (A) service manager, Standard Steel Car Co., and secretary, Pittsburgh Model Engine Co., *Pittsburgh*, (mail) Standard Steel Car Co.

WALTERS, R. F. (A) branch manager, Carr Fastener Co., *Detroit*, (mail) 190 Moss Avenue.

WARE BROS. CO. (Aff) 1010 Arch Street, *Philadelphia*. Representatives: Albert P. Cardwell, editor *Vehicle Monthly*.

WEINBERG, FRED (M) consulting engineer, General Motors Corporation, New York City, (mail) 42 Watson Street, *Detroit*.

WINKLESS, P. E. (J) mechanical engineer, Acme Steel Goods Co., *Chicago*, (mail) 7350 Drexel Avenue.

WISENBURGH, C. B. (A) Western sales manager, Standard Steel & Bearings, Inc., Philadelphia, (mail) 1511 Kresge Building, *Detroit*.

YERAM, ZAKAR A. (M) chief draftsman, general supply department, *Fairfield, Ohio*, (mail) engineer office, Aviation General Supply Depot.

Applicants *for* Membership

The applications for membership received between Nov. 24 and Dec. 22, 1920, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

AHLENE, C. M., sales and service engineer, Borg & Beck Co., *Moline, Ill.*

APOR, EMIL L., experimental work, Fairbanks-Morse & Co., *Beloit, Wis.*

BACON, CHESTER A., chief engineer, Auburn Division, Bowen Products Corporation, *Auburn, N. Y.*

BAKER, HAMMOND D., district sales manager, Roller-Smith Co., *Bethlehem, Pa.*

BARTLETT, LEROY A., factory representative, Detroit Steel Products Co., *Detroit*.

BARTON, LOY E., student, University of Arkansas, *Fayetteville, Ark.*

BEVERIDGE, FIRST-LIEUT. JOHN, JR., chief of engines branch, property division, Air Service, *Washington*.

BLAKE, E. A., in charge of experimental department, Transport Truck Co., *Mount Pleasant, Mich.*

BONELL, RALPH K., engineer, C. H. Wills & Co., *Marysville, Mich.*

CARPENTER, FIRST-LIEUT. CHARLES L., Quartermaster Corps, *Camp Dodge, Iowa*.

CASTRICONE, JOHN A., superintendent, Pittsburgh Model Engine Co., *Pittsburgh*.

CRAMER, V. C., F. S. Carr Co., 31 Beach Street, *Boston*.

CURRIE, CARLETON H., assistant in mechanical engineering department, Michigan Agricultural College, *East Lansing, Mich.*

DIFFENBAUGH, CAPT. HARRY, Quartermaster Corps, *Camp Devens, Mass.*

DONAHUE, FRANK W., treasurer, F. W. Donahue Co., Inc., *New York City*.

FIRST, HARRY V., designing engineer, Root & Van Dervoort Engineering Co., *East Moline, Ill.*

FOSKETT, MAYNARD L., chief engineer, Charleston Steam Tractor & Truck Mfg. Co., *Dunbar, W. Va.*

FULDA, RENE, civil engineer and director, Societe Francaise des Automobiles White, *Paris, France*.

GAGE, OSCAR THOMAS, assistant general foreman, Sheridan Motor Co., *Muncie, Ind.*

GEIGER, JOHN W., research assistant and instructor, Purdue University, *Lafayette, Ind.*

GIFFORD, ALBERT J., partner, Leland-Gifford Co., *Worcester, Mass.*

GOTTSCHAU, C. M., mechanical engineer, Great Western Sugar Co., *Denver*.

GRUNDY, GEORGE H., general sales manager, Poldi Steel Corporation of America, *New York City*.

HACH, EDWARD C., designer, Saxon Motor Car Corporation, *Detroit*.

HART H. P., chief engineer, Bollstrom Motors, Inc., *St. Louis, Mich.*

HUNT, WILLIAM H., JR., automotive engineer, First Heavy Mobile Shop, *Camp Meade, Md.*

INFIORATI, M. E., JR., chief engineer and assistant general manager, J. M. Lapointe Co., *New London, Conn.*

KAESS, CHARLES A., general manager, Automobile Crank Shaft Corporation, *Detroit*.

KEMP, JOHN M., buyer, Hinkley Motors Corporation, *Detroit*.

KOETZLA, DAVID J., automobile race driver, Stratford Hotel, *Chicago*.

KULP, A. DENNISON, automotive engineer, Standard Oil Co. of California, *San Francisco*.

LAZARNICK, NATHAN, proprietor, Commercial Photography, 246 West 42nd Street, *New York City*.

LEVENE, BENJAMIN, Levene Motor Co., *Philadelphia*.

MOUGET, MARCEL G., mechanical engineer, Midwest Engine Co., *Indianapolis*.

MUELLER, FRANK G., chief engineer, Maccar Truck Co., *Scranton, Pa.*

MULLER, MICHAEL, sales engineer, Vacuum Oil Co., *Chicago*.

MURRAY, W. T., electrical work and storage batteries, I. J. Cooper Rubber Co., *Nashville, Tenn.*

NORELIUS, EMIL F., consulting engineer, *Minneapolis*.

PANNELL, ERNEST V., engineer, British Aluminum Co., Ltd., *London, England*.

PATRICK, FRANK E., sales representative, Cuno Engineering Corporation, *Meriden, Conn.*

PATTEN, RAYMOND E., body engineer and chief draftsman, Colonial Motors Corporation, *Boston*.

PITTMAN, KNOWLES, sales manager, Electric Steel Co., *Chicago*.

PRENTICE, WILLIAM G., gage supervisor, Eaton Axle Co., *Cleveland*.

PRINKEY, JOHN WARD, mechanical engineer, Dayton Engineering Laboratories Co., *Dayton, Ohio*.

ROESCH, H. A., chief inspector, Moline Engine Co., *East Moline, Ill.*

SELLSTROM, ELMER W., assistant general manager, Dahlstrom Metallic Door Co., *Jamestown, N. Y.*

SHAKESPEARE, MONROE, engineer, Shakespeare Co., *Kalamazoo, Mich.*

SMITH, GEORGE AUSTIN, automotive sales department, Electric Storage Battery Co., *New York City*.

SPEICHERT, OTTO C., assistant superintendent, Pittsburgh Model Engine Co., *Pittsburgh*.

STEADMAN, CLAUDE A., chassis and motor layout, C. H. Wills & Co., *Marysville, Mich.*

TAWRESEY, JOHN S., assistant to chief engineer, Standard Steel & Bearings, Inc., *Philadelphia*.

TEER, DONALD M., vice-president and general manager, Vulcan Engineering Co., *Jackson, Mich.*

THOMPSON, J. K., president and general manager, Auto Engineering Co., *Detroit*.

TORRESEN, CAREL THEODORE, chief draftsman, tank, trailer and tractor division, Ordnance Department, *Cleveland*.

VAN SANDWYK, MARINUS C., automobile mechanic, Sweeney Auto School, *Kansas City, Mo.*

VICKERS, HARRY F., engineer, Arthur L. Eaton, *Los Angeles, Cal.*

WALLACE, GEORGE B., technical head of tractors division, General Motors Export Co., *New York City*.

WEST, MYERS BURTON, salesman, Goodyear Tire & Rubber Co. of California, *San Francisco*.

WHITING, LIEUT. EDMUND ALDEN, bureau of construction and repair, Navy Department, *Washington*.

WILLIAMS, CHESTER P., sales engineer, Northway Motors Sales Co., *Boston*.

WREAKS, HUGH T., Detroit manager, Boston Insulated Wire & Cable Co., *Detroit*.

YEAGER, HENRY M., factory manager, Fedders Mfg. Co., Inc., *Buffalo*.